This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

~~H. H. 9. 24~~

8 d : 14

LIBER COLL. OMN. ANIM. FIDEL. DEFUNCT. IN OXON.

1933 e. 178

GIVEN TO THE LIBRARY
BY ALL SOULS COLLEG
MCMXXVI

600036560Q

A

MANUAL OF CHEMISTRY;

CONTAINING

THE PRINCIPAL FACTS OF THE SCIENCE, ARRANGED IN THE
ORDER IN WHICH THEY ARE DISCUSSED AND ILLUSTRATED
IN THE LECTURES AT THE ROYAL INSTITUTION
OF GREAT BRITAIN.

BIBL. CODR. COLL. OMN. ANIM. OXON.

BY

WILLIAM THOMAS BRANDE,

Secretary of the Royal Society of London; Fellow of the Royal Society of Edinburgh; Member of, and
Professor of Chemistry in the Royal Institution of Great Britain; Professor of Chemistry and
Materia Medica to the Society of Apothecaries of the City of London; Member of the
Geological Society of London; Honorary Member of the Literary and
Philosophical Society of New York; of the Physico-Medical
Society of Erlangen; and of the Pharmaceutical
Society of Petersburgh.

SECOND EDITION, IN THREE VOLUMES.

VOL. III.

LONDON:
JOHN MURRAY, ALBEMARLE-STREET.
1821.

BODLEIAN LIBRARY
17
JUN
1926
OXFORD

LONDON:
PRINTED BY WILLIAM CLOWES,
Northumberland-court.

CONTENTS,

VOL. III.

CHAPTER VIII.

Page

OF VEGETABLE SUBSTANCES 1

SECTION I. Of the Structure and Growth of Plants, and of the Chemical Phænomena of Vegetation 2

II. Of the Composition and Analysis of Vegetable Substances, and of their ultimate and proximate Principles 10

III. Gum 18

IV. Sugar 21

V. Starch 29

VI. Gluten 35

VII. Extractive Matter, Lignin, &c. . 38

VIII. Tannin 44

IX. Colouring Matter, &c. . . . 47

X. Wax 53

XI. Fixed Oil 55

XII. Volatile Oils 58

XIII. Camphor 61

XIV. Resins 64

Page
SECT. XV. Narcotic Principles 69
XVI. Bitumens, Coal, &c. 75
XVII. Vegetable Acids 78
XVIII. Of the Parts of Plants 108
XIX. Phænomena and Products of Fermentation 128

CHAPTER IX.

OF ANIMAL SUBSTANCES 172
SECTION I. Of the ultimate Principles of Animal Matter, and of the Products of its destructive Distillation . . . 173
II. Blood 176
III. Milk 182
IV. Bile 186
V. Lymph, Mucus, Pus, &c. . . 188
VI. Urine, Urinary Calculi, &c. . . . 190
VII. Cutis, or Skin; Membrane, &c. . 203
VIII. Muscle, Ligaments, Horn, Hair, &c. 207
IX. Fat, Spermaceti, &c. . . . 208
X. Cerebral Substance 212
XI. Shell and Bone 213
XII. Animal Functions 216

CHAPTER X.

GEOLOGY.

I. General Remarks on the Objects of Geological Science. Sketch of the Theories of Burnet, Woodward, Leibnitz, Whiston, Whitehurst, and Buffon. Wernerian and Huttonian Theories 229

Page

SECT. II. Of the Succession of Strata incrusting the Globe, and of the Stratification of Britain in particular. Of Granite and other Primary Rocks 247

III. Of Stratified Rocks, and of the Transition and Secondary Formations of Werner.—Rock-salt, Coal, Alluvial Matters, Basalt . . . 275

IV. Of Metallic Veins. Of the General Causes of the Decomposition of Rocks. Of Volcanos. Of the Analysis of Soils . . . 304

APPENDIX.

Tabular View of the Equivalent Numbers of Vegetable and Animal Products, and of their Combinations 345

INDEX.

ADDENDA.

At page 171 of this volume the reader is requested to insert the following paragraphs:

1930*. When acetic acid and alcohol are repeatedly distilled together, a portion of *acetic ether* is formed, which has a peculiar and agreeable taste and smell, and a specific gravity of about .860 at 60°. It boils at about 160°, is highly inflammable, and emits acetic acid among its products of combustion. This ether is directed in some of the foreign Pharmacopœiæ for medical use, and the following is perhaps the best process for its production. Introduce into a tubulated retort 3 parts of acetate of potassa, 3 of alcohol, and 2 of sulphuric acid, and distil to dryness. To the product add one-fifth its weight of sulphuric acid, and draw off by a gentle heat a quantity of ether equal to that of the alcohol originally employed.

Acetic ether is much more soluble in water than sulphuric ether: according to M. Thenard, water at 60°

dissolves about a 7.5 part of its weight, and the solution is permanent. Caustic potassa decomposes it, and forms acetate of potassa.

Oxalic, citric, tartaric, and benzoic acids have been employed in the formation of ethers; the presence of a mineral acid is indispensable to their formation.—URE's *Dictionary*, ART. *Ether*.

A

MANUAL OF CHEMISTRY.

CHAPTER VIII.

OF VEGETABLE SUBSTANCES.

1508. HAVING in the preceding chapters considered the properties of the elementary substances, and such of their compounds as can be artificially formed, or are found in the mineral world, we proceed in this and in the succeeding chapter to examine the states of combination in which they occur in organic substances.

The several sections of the present chapter will relate to the formation of vegetable substances and their chemical physiology; to the analysis of vegetable products, and the properties of their proximate component parts; and to the phænomena and products of fermentation.

Section I. *Of the Structure and Growth of Plants, and of the chemical Phænomena of Vegetation.*

1509. In examining the external structure of a perfect and full-grown vegetable, or plant, the essential organs of which it is observed to consist are the root, the stem, the leaves, the flowers, and the seeds.

The *root* serves to attach the plant to the soil, and is one of its organs of nutriment; in its structure it closely resembles the stem, of which it may be regarded as a continuation, terminating in more or less minute ramifications, analogous to the branches deprived of leaves. The *stem* is usually erect and subdivided into *branches* which bear the *leaves* and *flowers*, and upon which the *seeds* are ultimately produced.

1510. When a branch of a tree is cut transversely it exhibits a *cortical portion*, or *bark*; *wood*; and *pith*, or *central medullary substance*.

The bark is subdivisible into an external layer or *cuticle*, under which is a *cellular substance* lying upon the innermost part, or *cortical layers*.

1511. The *cuticle* extends over every part of the plant; it allows of absorption and transpiration, and being generally transparent, at least upon the leaves and flowers, it admits the influence of light. The cuticle varies in texture and appearance in different plants. On the currant and elder tree it is smooth and scales off: on the fruit of the peach, and on the leaf of the mullein, it is covered with wool; on the leaf of the white willow, it is silky; in several plants, it is covered with hair and bristles, which in the nettle are perforated and contain a venomous fluid: on the plum and upon many leaves, it is varnished with a resinous exudation, which prevents injury from rain: it is fungous on the bark of the cork tree: and on grasses, on the equisetum, and especially on different species of the rattan, it is covered with a glassy network of siliceous earth.

Silica is also found in the hollow stem of the bamboo, constituting the substance called *tabasheer*, the optical properties of which are peculiar, and have been described by Dr. Brewster.—*Phil. Trans.* 1819.

1512. Under the cuticle, or epidermis, is the *parenchyma;* a soft substance, appearing under the microscope of a honeycombed or hexagonal cellular structure, resulting from the mechanical laws which influence the pressure of soft cylinders.

1513. The *cortical layers* appear of a tubular and fibrous texture, and with the cellular substance receive and elaborate the sap. In the older branches and trunks of trees, the bark consists of as many layers as they are years old; the innermost layer has been called the *liber*, in which the most essential vital functions of the plant appear to go on, and by which a new layer of wood is annually secreted.

1514. The *wood* consists of an outer stratum of living wood called the *alburnum*, or *sap-wood;* and an inner dead part, or *heart-wood*. In the alburnum, which is tubular, the sap appears to rise from the roots; it passes into the leaves, where it undergoes changes, and thence enters the vessels of the inner bark, in which new parts are produced, and which is thus enabled to generate new wood.

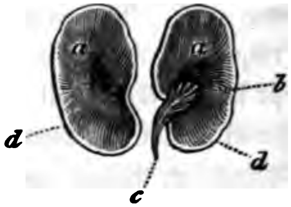
When the tubular structure is examined by a magnifier, it appears composed of vessels, some of which are simple, others perforated in various ways, and others spiral. The fibres of the wood consist of concentric and diverging layers, which have been called the *spurious* and the *silver grain*.

1515. The *pith* occupies the centre of the wood; it is very variable in quantity in plants of different ages, and appears not to be of essential importance. It probably sometimes serves as a reservoir of moisture.

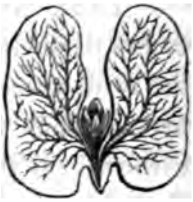
1516. The *leaves* are highly vascular, and appear composed of a woody skeleton, supporting a tubular and cellular structure. They allow of evaporation and absorption, and in them the sap is concocted and rendered fit for the production of new parts. The absorption and evaporation principally take place upon the lower surface of the leaf. In most plants the leaves are annually re-produced.

1517. The *flower* consists of the *calyx*, or green support of the *corolla*, or *floral leaves* ; and of the *pistil* and *stamens*. The pistil is surmounted by the *style*, and is connected with a vessel containing the rudiments of the seeds. The stamens are surmounted by *anthers*, covered with a fine powder called the *pollen*, and which, being deposited upon the style, renders the seeds productive.

1518. The *seed* is extremely various in form. It consists essentially of the *cotyledon*, the *plume*, and the *radicle*. The cotyledon contains the matter necessary for the early nutrition of the young plant. Sometimes it is single, sometimes double, and sometimes divisible into several lobes. The plume afterwards produces the stem and leaves, and is enveloped by the cotyledons ; the radicle generally projects a little, and when the seed vegetates, it becomes the root. These parts are usually enveloped in a common membrane, and are well seen in the garden bean, represented in the annexed cut. *aa* are the cotyledons; *b* the plumula; *c* the radicle; *d d* the external membrane.



1519. When a seed is placed under favourable circumstances the different parts begin to grow; the membranes burst, the plumula gradually expands and rises to the surface of the soil, and the radicle puts forth ramifications, and becomes a root. These changes constitute *germination*. The cotyledons, originally insipid and farinaceous, become sweet and mucilaginous, and furnish materials for the early nutriment of the young plant, before its root and leaves are adequate to their full functions; and vessels are observed ramifying throughout the cotyledons for this purpose, as here represented.



When the root and stem have acquired a certain degree of vigour, the cotyledons either rot away, or become leaves; and the plant then derives its nourishment by the absorbing powers of the root and leaves, the former collecting materials from the soil, the latter from the atmosphere.

The circumstances requisite for the healthy germination or growth of a seed are principally the f lowing: 1. A due temperature, which is alw above the freezing point, and below 100°. 2. Moisture in due proportion. 3. A proper access of air, the oxygen of which is slowly converted into carbonic acid. The joint operation of these agents also is required; for seeds exposed to air and moisture, but kept below 32°, will not grow, though they are not injured by the low temperature: nor will a seed vegetate without air, though moisture be present and a sufficient temperature; this is shown by burying seeds deep in the soil, and by the spontaneous vegetation upon newly-turned earth, in which seeds had existed, but through absence of oxygen had been unable to vegetate. Hence in all cases of tillage the seeds should be so sown as that the air may have access; in sandy soils this is easily attained, but in clayey soils the adhesiveness of the materials is often the cause of their unproductiveness.

1520. As the plant advances to perfection, it becomes dependant upon the air and soil for its nutriment: the roots absorb moisture and other materials; and the leaves, while they exhale moisture, frequently absorb carbon from the carbonic acid present in the atmosphere, and evolve oxygen (*Prefatory History of Chemistry*, p. 132.) This evolution of oxygen takes place while plants are exposed to the solar rays, and appears one of the most efficient causes hitherto suggested of the purification and renovation of the air. In the night-time, the leaves of plants always exhale carbonic acid, and at all times if the leaves be dying or unhealthy. There are also certain plants which appear under all circumstances rather to deteriorate than renovate the air; on the whole, however, the balance is in favour of amelioration (DAVY's *Agricultural Chem.* 4to. p. 195.) though the disappearance of the enormous quantities of carbonic acid gas continually pouring into our atmosphere, can, I think, scarcely be referred to the purifying action of vegetables alone.

Under certain circumstances, the leaves of plants also absorb a considerable portion of aqueous vapour and water, as is shown by the resuscitation of a drooping plant, on sprinkling it with water, or exposing it to a humid atmosphere. It is probable that, in healthy vegetation, the absorption of water by the leaves takes place in the night season chiefly, and that their principal function in the day is that of transpiration. Upon these subjects the reader may consult SAUSSURE's *Recherches Chimiques sur la Végétation.*

1521. The fluid found in the vessels of plants is called their *sap*; it has a motion in the vessels, and appears to rise from the roots in a series of tubes in the alburnum; it then circulates in the leaves, becomes changed considerably in composition, and enters the vessels of the inner bark, enabling it to produce a new layer of wood, and to form the peculiar secretions which belong to it, and which, in smaller quantity, are also found in other parts of the vegetable.—See *Prefatory History of Chemistry*, p. 104.

The cause of the motion of the sap has never been satisfactorily accounted for, though it is, perhaps, principally referable to the contraction and expansion produced by changes of temperature.

That the sap ascends in the *alburnum*, and descends in the *liber*, or inner bark, is shown by making an incision into the former and latter. The wound of one will exude upon its lower surface, and of the upon its upper surface: and if a circular strip of bark be removed from a small branch of a tree near the stem, there will, of course, be an accumulation of sap in that branch, and its produce of leaves, flowers, and fruit, is often remarkably increased by such an operation.

If the alburnum, on the contrary, of a branch be completely divided, it dies, as nourishment is then excluded; a fact pointed out by Mr. Knight; who has also shown, in proof of the situation of the vessels carrying the ascending sap, that coloured fluids applied to the root always pass upwards in the alburnum only.—*Phil. Trans.* 1801.

1522. The sap of plants is of very various composition, and contains, besides certain proximate vegetable principles, several saline substances, especially the acetates of potassa, and of lime: it also often exhibits traces of uncombined vegetable acids. The sap of the elm, beech, hornbeam, and birch, have been examined by Vauquelin, (*Annales de Chimie*, xxxi.) Dr. Prout has given some account of the sap of the vine; and Professor Scherer has analyzed the sap of the common maple. (THOMSON'S *System*, iv. 212.) It is, however, almost impossible to collect the ascending sap without admixture of some other juices of the plant, so that the analyses only afford approximations to its real composition.

1523. The heat of plants is in many instances above that of the surrounding medium, and there are cases on record in which a very marked elevation of temperature has been observed in them, but upon this subject we have as yet no accurate researches.—SMITH'S *Introduction to Botany*, p. 89.

1524. Though the presence of light, air, and moisture, aided by a due temperature, are the principal requisites for the growth of plants, these are not the only essentials, for they also derive nutriment from the soil, which becomes impoverished by their growth, and ultimately incapable of supporting healthy vegetation, unless aided by manures. It is thus that the alcaline, earthy, and saline ingredients of plants are furnished, and quick-growing vegetables require a constant supply of these substances.

1525. *Manures* are of vegetable, animal, or mineral origin. The two former are capable of affording two of the essential ingredients of plants, namely, carbon and hydrogen; they may also yield some of the more immediate principles found in vegetables. The mere existence, however, of vegetable matter in the soil, is not sufficient to constitute it a manure; it must be reduced to a soluble state; to a state in which it can be absorbed by the roots of a growing vegetable; this is often effected by fermentation or putrefaction, or by applying the vegetable matter in a green state, as by ploughing in a green crop. Where the vegetable matter is in an inert insoluble form, it will be of no avail unless rendered active and soluble, which is effected either by mixing it with such kinds of animal matter as undergo quick putrefaction, and are themselves propitious to the growth of vegetables; such, for instance, as dung, rotten fish, or decaying parts of animals; or, by the operation of alcaline bodies, such as quicklime, *&c.*

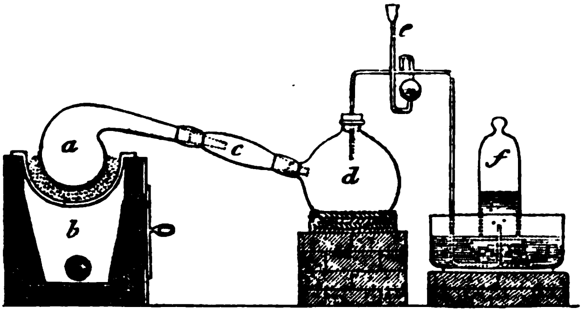
When newly burned lime is strewed over a soil containing inert vegetable matter, it acts upon it, and renders it more or less soluble; while the lime, by absorbing moisture and carbonic acid, is slaked, and passes into the state of chalk, which is not hurtful to vegetables, and often a very useful addition to the soil: but when limestone contains magnesia, that earth remains caustic, and sometimes proves highly injurious.—DAVY's *Agricultural Chemistry*, 4to. p. 234.

SECTION II. *Of the Composition and Analysis of Vegetable Substances, and of their ultimate and proximate Principles.*

1526. THE *ultimate* principles of vegetable substances are few in number; but by being combined in various proportions, they give rise to a series of compounds materially differing from each other, and which may be called their *proximate* component parts.

Carbon, hydrogen, and oxygen, are the principal ultimate components of vegetables: some afford nitrogen; in some there are traces of sulphur; and in their sap or juices we find small proportions of potassa and of lime, sometimes of soda and of magnesia; these bodies are combined with acids, and chiefly obtained by burning or incineration. It has already been said, that some plants contain silica; sulphate of lime is found in clover, nitrate of potassa in the sap of the sun-flower, and nitrate of soda in barley. Common salt is a very frequent ingredient in marine plants; phosphate of lime is found in oats and some other seeds; and nearly all vegetables yield traces of oxide of iron, and many of oxide of manganese. In SAUSSURE's *Chemical Researches on Vegetation*, and in the fourth volume of Dr. THOMSON's *System of Chemistry*, are copious tables, showing the earthy and saline constituents of vegetables.

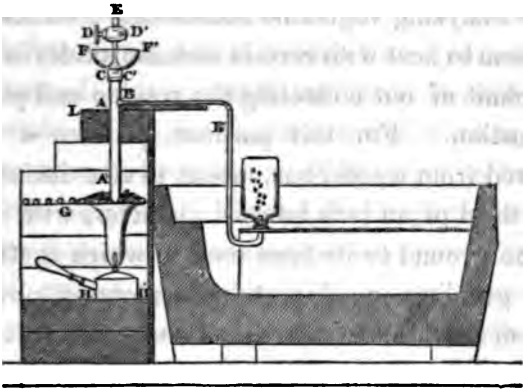
1527. When vegetable substances are submitted to destructive distillation, the carbon, hydrogen, and oxygen which they contain enter into new arrangements, and a variety of *products* are obtained, differing in quantity and quality according to the nature of the vegetable substance, and varying with the mode of distillation. Water, empyreumatic oil, acids, carbonic oxide and acid, and carburetted hydrogen, are in this way formed; and, if the vegetable contain nitrogen, ammonia may be obtained. A portion of charcoal, with the saline and earthy ingredients, remains in the retort. By a careful analysis of these products, the relative proportions of carbon, hydrogen, and oxygen, and of nitrogen, if present, may be judged of. The following form of apparatus may be used in these researches:



a is a glass or earthen retort, containing the vegetable substance to be decomposed, and placed in a sand heat upon the furnace *b*, which is gradually raised to a red heat. It is connected by the adapter *c* with the receiver *d*, which is kept cool for the condensation of the liquid products; the gases pass into the bell-glass *f* standing over mercury. *e* is a tube of safety, to allow for sudden expansion or contraction; there being in its lower part a small quantity of mercury which is occasionally elevated or depressed. The joints are secured by lute.

1528. An improved mode of ascertaining the relative proportions of the ultimate component parts of vegetable products has been devised by MM. Gay-Lussac and Thenard, (*Recherches Physico-Chimiques*, Tom. ii.) It consists in burning the vegetable substance with chlorate of potassa (546.) The requisite proportion of the chlorate, ascertained by previous experiment, is mixed with a given weight of the vegetable matter, and made into a small ball, which is dried, and burned in the apparatus described in the opposite page. The gases are collected over mercury. The carbonic acid is absorbed by solution of potassa: if nitrogen be present, it will be found in the residuary gas; if carburetted hydrogen has been disengaged, its quantity and composition may be ascertained by detonation with oxygen. There should, however, always be allowance made for the production of excess of oxygen: thus the quantity of carbon is estimated from that of the carbonic acid formed; the quantity of hydrogen is deduced from that of the oxygen which has disappeared for the production of water; and the quantity of oxygen is learned by the remaining excess.

The details of the process will be found in the fourth volume of M. THENARD's *Traité de Chimie*, with the following arrangement and description of the apparatus.



A hole is made through a brick, L, and the glass tube AA is passed through it as far as to the small lateral tube BB, which passes into the mercurial trough. The lower extremity of the tube rests upon the grate G, where it is to be heated red-hot by charcoal, inflamed by the lamp H. A brass cock is fitted by grinding, to the tube CC. It has a solid plug, DD, in which is a cavity large enough to contain one of the balls to be analyzed, and which is introduced at the opening E. The plug is then turned round, and the ball falls into the red-hot part of the tube, where it burns, the gases passing into the mercurial apparatus. FF is a basin, into which ice may be introduced to keep the metallic parts of the apparatus cool. It is convenient to case the lower part of the tube A in iron, as it is sometimes blown out at that part by the expansion within.

Further directions respecting this process, with some observations upon it by Mr. Daniell, will be found in

Mr. Children's translation of M. Thenard's volume on Analysis.

1529. A simpler, and in some respects, preferable means of analyzing vegetable substances, consists in exposing them to heat with certain metallic oxides in vessels which admit of our collecting the residue and products of combustion. For this purpose, procure a copper tube, bored from a solid bar, about twelve inches long, and one-third of an inch internal diameter, with a bent brass tube ground to its open end, to which is attached, also by grinding, a glass tube containing powdered muriate of lime, and bent so as conveniently to pass under the shelf of the mercurio-pneumatic apparatus; the muriate of lime may be kept in its place by some loose amianthus, and the weight of the glass tube should be carefully ascertained. Fill the brass tube loosely with dry amianthus; weigh out 3 grains of the vegetable substance to be analyzed, and mix these intimately with 120 grains of finely-powdered peroxide of copper; put this mixture into the bottom of the copper tube, and afterwards fill it up loosely with oxide of copper; then attach the brass and glass tubes, and arrange the apparatus so that the open end of the latter may be brought under an inverted jar of mercury, and the copper tube placed in a small furnace and surrounded with burning charcoal, taking care to apply the heat in the first instance to the upper part of it, and afterwards, to the bottom containing the vegetable matter; care should be taken to make the whole of the copper tube gradually dull red, and to keep the brass tube as cool as possible by a damp cloth. During this operation the carbon of the vegetable matter will be converted into carbonic acid, and collected over the mercury; the nitrogen, if any, will be mixed with it, and the hydrogen will be converted into water, and absorbed by the muriate of lime. The carbonic acid may be absorbed by liquid potassa, and its bulk furnishes a datum upon which to calculate the proportion of carbon, while the increase of weight in the muriate of lime shows the quantity of water formed, and consequently the quantity of hydrogen in the matter subjected to analysis. If we find the aggregate weight of the carbon and hydrogen, or of the carbon, hydrogen, and nitrogen, equal to that of the original vegetable substance, no oxygen was present; but if there be a deficiency it may be referred to oxygen.

1530. In all analyses thus conducted, the vegetable substance should either be previously perfectly dried, or the quantity of adhering water, if there be any, allowed for, in summing up the results; with every precaution, however, the method is open to objections, and liable to several sources of fallacy. Indeed, although I have frequently made such experiments with every possible caution, I have in no one instance gained satisfactory results; the quantity of carbon may, it is true, be obtained with sufficient accuracy; but the greatest difficulty attends the collection of the water which is formed, and all estimates that I have been able to make of the relative proportions of oxygen and hydrogen have been so exceedingly at variance in different trials, as entirely to shake my confidence in the accuracy of the mode of analysis; and the same difficulty occurs in respect to the nitrogen. When, therefore, I see the results of the analysis of a single grain of vegetable matter detailed to the third decimal number, I cannot but suspect that theory has more share in the result than experiment, more especially when such analysis is made the basis of an atomical calculation.

1531. By subjecting different vegetable substances to ultimate analysis, MM. Gay-Lussac and Thenard consider themselves warranted in drawing the following conclusions:

a. A vegetable substance is always acid, when the oxygen which it contains is to the hydrogen, in a proportion greater than is necessary to form water, or where there is *excess of oxygen.*

b. A vegetable substance is resinous, oily, or alcoholic, where the oxygen is to the hydrogen in a less proportion than in water, or where there is *excess of hydrogen.*

c. A vegetable substance is neither acid nor resinous, but saccharine, mucilaginous, *&c.*, where the oxygen and hydrogen are in the same relative proportion as in water, or where there is *no excess of either.*

To the correctness of these results, there are some exceptions which have been pointed out by M. Saussure (THOMSON's *Annals*, Vol. vi.,) and by Mr. Daniell (*Journal of Science and Arts*, Vol. vi. p. 326,) and which tend considerably to shake our confidence in their entire accuracy.

The following Table exhibits the results of the analysis of several substances, by the mode above described. THENARD's *Treatise on Chemical Analysis, translated by* A. MERRICK.

SUBSTANCES ANALYZED.	Carbon contained in that body.	Oxygen contained in that body.	Hydrogen contained in that body.	Or supposing the oxygen and hydrogen to be in the state of water in the vegetable substance.		
				Carbon.	Water.	Excess of Oxygen.
Sugar . . .	42.47	50.63	6.90	42.47	57.53	0
Gum arabic	42.23	50.84	6.93	42.23	57.77	0
Starch . . .	43.55	49.68	6.77	43.55	56.45	0
Sugar of milk .	38.825	53.834	7.341	38.825	61.175	0
Oak	52.53	41.78	5.69	52.53	47.47	0
Beech . . .	51.45	42.73	5.82	51.45	48.55	0
Mucous acid .	33.69	62.67	3.62	36.69	30.16	36.15
Oxalic acid .	26.57	70.69	2.74	33.57	22.87	50.56
Tartaric acid .	24.05	69.32	6.63	24.05	55.24	20.71
Citric acid . .	33.81	59.86	6.33	33.81	52.75	13.44
Acetic acid .	50.22	44.15	5.63	50.22	46.91	2.87
						hydrogen in excess.
Resin of turpent.	75.94	13.34	10.72	75.94	15.16	8.90
Copal . . .	76.81	10.61	12.58	76.81	12.05	11.14
Wax . . .	81.79	5.54	12.67	81.79	6.30	11.91
Olive oil . .	77.21	9.43	13.36	77.21	10.71	12.08

1532. The *proximate* principles of vegetables are chiefly separable from each other by the action of certain solvents, of which the principal are cold and hot water, alcohol, ether, and a few of the acids. The manner of applying these will be made more obvious by the details in the following sections, than by any general account which could here be given of the various steps of the analysis. The number of proximate principles which are thus capable of being distinguished and separated from each other, is considerable ; those which have been most accurately examined are enumerated in the following Table, and will each form the subject of a separate section ; while those which are less perfectly known, will be adverted to under the titles of those which they most nearly resemble.

1 Gum.
2 Sugar.
3 Starch.
4 Gluten.
5 Extractive matter and Lignin.
6 Tannin.
7 Colouring matter.
8 Wax.
9 Fixed oil.
10 Volatile oil.
11 Camphor.
12 Resins.
13 Narcotic principles.
14 Bituminous substances.
15 Vegetable acids.
  a. Tartaric acid.
  b. Oxalic acid.
  c. Benzoic acid.
  d. Citric acid.
  e. Malic acid.
  f. Gallic acid.

SECTION III. *Gum.*

1533. GUM is contained in considerable quantities in the sap of many vegetables, and frequently appears as a spontaneous exudation. *Gum arabic* may be taken as a specimen of pure gum. Its specific gravity is about 1.4. It has a slightly yellow tint, and is translucent, inodorous, and insipid. It dissolves in water, forming a viscid solution, or *mucilage*, from which it may be obtained in its original state by evaporation; it is insoluble in alcohol, which, therefore causes a white precipitate in its aqueous solutions; it is also insoluble in ether and oils; it undergoes no change by exposure to air, and its aqueous solution does not ferment, but only becomes slightly sour when kept for a long time.

1534. Gum is decomposed by sulphuric and nitric acids: the former produces water, acetous acid, and charcoal; the latter, among other products, converts a portion of the gum into a white acid substance, called the *mucous acid*, and which is analogous to that obtained from sugar of milk, or *saccholactic acid*, under which head its preparation is mentioned: malic and oxalic acids are also formed.

Dilute sulphuric, and muriatic acids, dissolve gum without change.

1535. The alcalies, and solutions of the alcaline earths, also dissolve gum, and the addition of acids occasions its partial precipitation without having undergone much apparent alteration. It combines with a few of the other metallic oxides. A strong solution of permuriate of iron, dropped into a concentrated mucilage, forms a brown jelly of difficult solubility. Silicated potassa also occasions a white flaky precipitate in dilute mucilage, and is, according to Dr. Thomson, a very delicate test of gum. By mixing caustic ammonia with a boiling solution of gum, and then adding subnitrate of lead, Berzelius obtained a white precipitate (*gummate of lead*) composed of

Gum	61.75
Oxide of lead .	38.25
	100.

If this compound be regarded as consisting of 1 proportional of gum, and 1 of oxide of lead, the number 170 might be assumed as the representative of gum, for 38.25 : 61.75 :: 104.5 : 169. But if we consider it as a compound of 2 of gum and 1 of oxide, then 85 would be the equivalent of gum, and the following numbers nearly agree with its composition, as deduced from experiment:

6	Proportionals of oxygen	7.5 + 6 =	45.0 =	53.
6	- - - - - - - - - hydrogen	1. + 6 =	6.0 =	7.
6	- - - - - - - - - carbon ..	5.7 + 6 =	34.2 =	40.
			85.2	100.

1536. Submitted to destructive distillation, gum affords carbonic acid and carburetted hydrogen gases, empyreumatic oil, water, and a considerable quantity of impure acetic acid, once considered as a peculiar acid, and distinguished by the term *pyromucous acid.*

1537. There are several varieties of gum differing a little from each other. *Cherry-tree gum* and *gum tragacanth* do not dissolve in cold water, but in other respects their properties resemble those of gum arabic. To these varieties the generic term of *Cerasin* has been given by some chemists.

SECTION IV. *Sugar.*

1538. SUGAR may be extracted from the juice of a number of vegetables, and is contained in all those having a sweet taste; that which is commonly employed is the produce of the *arundo saccharifera*, or *sugar cane*, a plant which thrives in hot climates. Its juice is expressed and evaporated with the addition of a small quantity of lime, until it acquires a thick consistency; it is then transferred into wooden coolers, where a portion concretes into a crystalline mass, which is drained and exported to this country under the name of *muscovado*, or *raw sugar*. The remaining liquid portion is *molasses*, or *treacle*.

1539. The following is a sketch of the process by which raw sugar is purified in this country.

Raw sugar is chosen by the refiner by the sharpness and brightness of the grain, and those kinds are preferred which have a peculiar grey hue. Soft-grained yellow sugars, although they may be originally whiter, are not so fit for the purposes of the manufactory, and it is for this reason that sugars from particular countries are never used: such are those from the East Indies, Barbadoes, *&c.* They do not possess the property of crystallizing so perfectly, and approach in this respect to the nature of grape sugar.

There appear to be two perfectly distinct kinds of saccharine matter; one, when pure, is transparent and colourless, and crystallizes under proper management in a regular form, generally in flattened six-sided prisms;

the other is uncrystallizable, and generally highly charged with colouring matter. This colouring matter is not, perhaps, essential to it, but may arise in the present case from the effect of fire, by the agency of which it is peculiarly prone to decomposition. We may mention, as familiar instances of these two, *white-sugar-candy* and *treacle*. The juice of the cane is composed of these ingredients, and though they are in some degree separated in our Indian colonies by the process of evaporation and filtration, yet the raw sugar which we receive contains still much of the latter combined with the former. The process of refining consists in further separating the two.

The proper sugar being selected, the *pans*, which resemble in some measure those used in the West Indies, are charged with a certain portion of lime-water, with which bullocks' blood is well mixed by agitation. They are then filled with the sugar, which is suffered to stand a night to dissolve. The use of the lime-water is not, as is generally supposed, to neutralize any free acid in the raw material: but, by combining with the molasses, to render it more soluble, and thus to facilitate its separation from the pure solid sugar. In the purer kinds, and more especially when the refined is again melted over for the purpose of bringing it to its utmost degree of purity, lime is not used, the quantity of molasses being so small as to be easily removed by the agency of water alone.

Fires are lighted under the pans early in the morning, and when the liquid begins to boil, the albumen of the blood coagulates and rises to the top, bringing all the impurities of the sugar with it. These are taken off with a skimmer. The liquid is kept gently simmering and continually skimmed, till a small quantity, taken in a metallic spoon, appears perfectly transparent: this generally takes from four to five hours. The whiteness of the sugar is not at all improved by this process, but is even sometimes deteriorated from the action of the fire; it only serves to remove all foreign impurities. When the solution is judged to be sufficiently clear, it is suffered to run off into a large cistern. The pans are then reduced to half their size by taking off their fronts, and a small quantity is returned into each. The fires are now increased, and the sugar made to boil as rapidly as possible, till a small quantity taken on the thumb is capable of being drawn into threads by the fore-finger. Nothing but practice can ascertain the exact point at which the boiling should be stopped: if it is carried too far, the molasses is again bound up with the sugar; and if it is not carried far enough, much of the sugar runs off with the molasses in the after-process. When this point is ascertained, the fire is instantly damped, and the boiling sugar carried off in basins to the *coolers*; a fresh quantity is then pumped into the pans, which is evaporated in the like manner.

When the sugar is in the coolers, it is violently agitated with wooden oars till it appears thick and granulated, and a portion taken on the finger is no longer capable of being drawn into threads. It is upon this agitation in the cooler that the whiteness and fineness of grain in the refined sugar depends. The crystals are thus broken whilst forming, and by this means the whole is converted into a granular mass, which permits the coloured liquid saccharine matter to run off, and which would be combined with the solid if suffered to form in larger crystals. This granular texture, likewise facilitates the percolation of water through the loaves in the after-process, which washes the minutely-divided crystals from all remaining tinge of the molasses. That this is the true theory of the whitening of sugar by the process of refining, appears from a comparison with the process for making candy. In this latter, the raw material is cleared and boiled exactly in the same manner ; but instead of being put into coolers and agitated, it is poured into pots, across which threads are strung, to which the crystals attach themselves : these are set in a stove, and great care is taken not to disturb the liquid, as upon this depends the largeness and beauty of the candy. In this state it is left for five or six days, exposed to a heat of about 95°, when it is taken out and washed with lime-water : this takes off the molasses from the outside, but a great quantity is combined in the crystals, and the consequence is, that candy is never whiter than the sugar from which it is made.

When the sugar has arrived at that granular state in the coolers above described, it is poured into conical earthen moulds, which have previously been soaked a night in water. In these it is again agitated with sticks, for the purpose of extricating the air-bubbles which would otherwise adhere to the sugar and the moulds, and leave the coat of the loaf rough and uneven When sufficiently cold, the loaves are raised up to some of the upper floors of the manufactory, and the paper stops being removed from their points, they are set, with their broad ends upward, upon earthen pots. The first portions of the liquid molasses soon run down, and leave the sugar much whitened by the separation. This self-clearance is much assisted by a high temperature; and when it is perfected, pipe-clay, carefully mixed up with water to the consistence of thick cream, is put upon the loaves to the thickness of about an inch: the water from this slowly percolates the loaves; and, washing the solid sugar from all remains and tinge of the molasses, runs into the pots. The clay is of no other use than to retain the water, and prevent its running too rapidly through the mass, by which too much of the sugar would be dissolved: a sponge, dipped in water, acts in the same manner. The process of *claying* is repeated four or five times, according to the nature of the sugar, and the degree to which it has been boiled. When the loaves are perfectly cleansed from all remains of the coloured fluid, they are suffered to remain some time for the water to drain off; when this is completed, they are set, with their faces down, when all remains of it return from their points, and it is equally diffused throughout: they are then set in a stove, heated to about 95°, and thoroughly dried.

The sirup, or the mixed solution of sugar and molasses which runs into the pots, is mingled in the next boilings with the solution of raw sugar in the pans, and again evaporated. It is divided according to its fineness; the first running containing, of course, more molasses, is reserved for the coarser loaves; whilst the last, being little else than a solution of sugar, is boiled into loaves, of the same degree of fineness as those from which it ran. The lowest sirups are boiled into what is called *bastard sugar*, from which the molasses runs with very little mixture of the solid sugar. This is called *treacle*, and is totally incapable of further crystallization.

The produce of 1 cwt. of raw sugar worked in this manner is, upon an average,

63 lbs refined
18 — bastard
27 — molasses
4 — lost weight, dirt, *&c.*
112

The process above described may almost be considered as mechanical. The only truly chemical parts of it are the clearing with blood, and the use of lime-water, which, leaving the solid sugar untouched, combines with the molasses, and rendering it in some measure saponaceous, facilitates its solution during the percolation of the water.

Attempts have lately been made to whiten the sugar during its boiling, by the addition of charcoal. This destroys some of the colouring matter of the molasses, and tends materially to whiten the sugar, especially if the charcoal employed be partly of animal origin.

Another attempt has been made to improve the process of claying, by the substitution of a strong solution of very white sugar for the clay. The idea was, that the water having a stronger affinity for the molasses than for the solid sugar, would, in its passage through the loaves, wash away the former, and leave the latter in its place, and that more weight and a closer grain would thus be obtained. The idea was ingenious but the advantages scarcely counterbalanced the additional expense of preparing the solution of fine sugar in the first instance.

1540. Sugar may be obtained from the sap of many other plants. It exists in large quantity in the sugar maple (*acer saccharinum*) and in the root of the common beet (*beta vulgaris*). In many ripe fruits sugar is a predominating ingredient; and in dried grapes, figs, *&c.*, it is often seen as a superficial incrustation. Though these kinds of sugar differ a little from each other, they can scarcely be regarded as distinct species.

1541. *Honey* is also a variety of sugar containing a crystallizable and an uncrystallizable portion, the predominance of one or other of which give to it its peculiar character; they may be partially separated by mixing the honey with alcohol, and pressing it in a linen bag; the liquid sugar being the most soluble, passes through, leaving a granular mass, which forms crystals when its solution in boiling alcohol is set aside. Honey also frequently contains wax, and a little acid matter.

1542. Sugar is a white brittle substance of a pure sweet taste, soluble in its own weight of water at 60°. Boiling water dissolves a considerably larger quantity. This solution is called *sirup ;* it is viscid, and furnishes crystals in the form of four and six-sided prisms, irregularly terminated. Sugar is soluble in alcohol, but much more sparingly so than in water.

1543. Nitric and sulphuric acids decompose sugar; the former converts it into oxalic acid; the latter evolves charcoal and produces water and acetous acid.

1544. The alcalis dissolve sugar, and destroy its sweet taste, which re-appears if an acid be added. When, however, the alcalis are left for a long time in the contact of sugar they effect a more important change, becoming carbonated and converting the sugar into gum. From a solution of sugar in lime-water, Mr. Daniell, who has obligingly furnished me with the principal materials of this section, obtained crystals of carbonate of lime and a portion of gum. The addition of phosphuret of lime to sirup produces an analogous change.—*Journal of Science and the Arts*, Vol. vi. p. 32.

1545. When protoxide of lead is digested with sugar and water, a portion is dissolved and afterwards separates in the form of a white insipid powder (*saccharate of lead,*) insoluble in water and composed, according to Berzelius, of

Sugar	41.74
Oxide of lead....	58.26
	100.00

1546. When sugar is exposed to heat it fuses, becomes brown, evolves a little water, and is resolved into new arrangements of its component elements. If suddenly elevated to a temperature of about 500°, it bursts into flame.

1547. The relative proportions of elements in gum and sugar appear from the experiments of Gay-Lussac (page 17,) to be nearly the same. The analyses of these two substances by Berzelius afforded slight differences only ; according to him they contain

Carbon....	41.906	Gum	.. 44.200	Sugar
Oxygen ...	51.306	= 100	.. 49.015	= 100
Hydrogen..	6.788		.. 6.785	

The equivalent of sugar, deduced from the analysis of the compound with oxide of lead, provided we regard that compound as containing 1 proportional of each of its components, is 74.7, a number not perfectly reconcileable with the ultimate of analysis of Berzelius, who regards sugar as composed of

6	Proportionals of carbon..	5.7 + 6 =	34.2..	44.5
5	- - - - - - - - - oxygen	7.5 + 5 =	37.5..	49.4
5	- - - - - - - - - hydrogen	+ 5 =	5. ..	6.1
			76.7	100.0

1548. *Manna* is an exudation from the *Fraxinus Ornus*, a species of ash, growing in Sicily and Calabria. It has a sweet and somewhat nauseous taste, and is used in medicine as a mild aperient. It is very soluble in water, and more soluble in alcohol than cane sugar; the latter solution deposits it in the form of a white spongy mass. Digested in nitric acid, it yields both oxalic and saclactic acids. Its solution in water does not appear susceptible of vinous fermentation.

SECTION V. *Starch.*

1549. STARCH, or *Fecula*, may be separated from a variety of vegetable substances; it is contained in the esculent grains, and in many roots. The process for obtaining it consists in diffusing the powdered grain or the rasped root in cold water, which becomes white and turbid; the grosser parts may be separated by a strainer and the liquor which passes deposits the starch, which is to be washed in cold water and dried in a gentle heat.

1550. The common process for obtaining the starch of wheat consists in steeping the grain in water till it becomes soft; it is then put into coarse linen bags, which are pressed in vats of water: a milky juice exudes, and the starch falls to the bottom of the vat. The supernatant liquor undergoes a slight fermentation, and a portion of alcohol and a little vinegar is formed, which dissolves some impurities in the deposited starch; it is then collected, washed, and dried in a moderate heat, during which it splits into the columnar fragments which we meet with in commerce, and which are generally rendered slightly blue by a little smalt.

1551. Pure starch is a white substance, insoluble in cold water, but readily soluble at a temperature between 160° and 180°. Its solution is gelatinous, becomes mouldy and sour by exposure to air, and by careful evaporation yields a substance resembling gum in appearance, which is a compound of starch and water. Starch is insoluble in alcohol and in ether, and occasions no precipitate in the greater number of metallic solutions; in solution of subacetate of lead, however, it occasions a copious precipitate. The most characteristic property of starch is that of forming a blue compound with iodine; it may be obtained by adding an aqueous solution of iodine to a dilute solution of starch.

Sulphuric and nitric acids dissolve starch, and slowly decompose it, or resolve it into new compounds. Dilute nitric acid dissolves it without decomposition, forming a greenish solution, which deposits starch upon the addition of alcohol. It is slowly soluble in muriatic acid, and insoluble in acetic acid.

Potassa, triturated with starch, forms a compound which is soluble in water.

Infusion of galls occasions a precipitate in the solutions of starch, which re-dissolves by heating the liquid to 120°. This property Dr. Thomson considers as characteristic of starch.

1552. By digesting subnitrate of lead in a boiling solution of starch, Berzelius obtained an insoluble compound, which he has termed *amylate of lead*, consisting of

72	starch.
28	oxide of lead.
100	

1553. It appears by a reference to the ultimate elements of starch and sugar, that they differ little in composition, and it is therefore not surprising that the former is easily convertible into the latter.

1554. The change of starch into sugar is always observed during the germination of seeds (1519), and in the process of *malting* a similar conversion is effected.

Malt is barley which has been made to germinate to a certain extent, after which the process is stopped by heat. The barley is steeped in cold water, and is then made into a heap, or *couch*, upon the maltfloor: here it absorbs oxygen and evolves carbonic acid; its temperature augments, and then it is occasionally turned, to prevent its becoming too warm. In this process the radicle lengthens, and the plume, called by the maltsters the *acrospire*, elongates; and when it has nearly reached the opposite extremity of the seed, its further growth is arrested by drying at a temperature slowly elevated to 150° or more. The malt is then cleansed of the rootlets.

According to Dr. Thomson, barley loses about 8 *per cent.* by converting it into malt, of which

1.5	is carried off by the steep-water
3.0	dissipated in the floor
3.0	roots separated by cleansing
0.5	waste
8.0	

1555. The following comparative analysis of unmalted and malted barley shows the change which has taken place in the operation.

Gum	5	14
Sugar	4	16
Gluten	3	1
Starch	88	69
	100 barley.	100 malt.

1556. Another mode of converting starch into sugar was discovered by M. Kirchoff; it consists in boiling it with very dilute sulphuric acid. A pound of starch may be digested in six or eight pints of distilled water, rendered slightly acid by two or three drachms of sulphuric acid. The mixture should be simmered for a few days, fresh portions of water being occasionally added to compensate for the loss by evaporation. After this process the acid is saturated by a proper proportion of chalk, and the mixture filtered and evaporated to the consistence of sirup; its taste is sweet, and, by purification in the usual way, it affords crystallized sugar. MM. de la Rive and Saussure have shown that the contact of air is unnecessary in the above process; that no part of the acid is decomposed, no gas evolved, and that the sugar obtained exceeds by about one-tenth, the original weight of the starch. M. de Saussure, therefore, concludes that the conversion of starch into sugar depends upon the solidification of water, a conclusion strengthened by the following comparative analysis.—Thomson's *Annals*, Vol. ii.

	100 Parts of Starch contain	100 Parts of Starch Sugar contain
Carbon	45.39	37.29
Oxygen	48.31	55.87
Hydrogen	5.90	6.84
Nitrogen	0.40	0.00
	100.00	100.00

1557. This analysis of starch is somewhat at variance with that given by Gay-Lussac; indeed the small portion of nitrogen cannot be considered as an essential component. Berzelius has given the following as the component parts of starch.—Thomson's *Annals*, Vol. v.

Carbon	43.481
Oxygen	48.455
Hydrogen	7.064
	100.000

of alcohol, gluten is separated into two principles, the one soluble and the other insoluble in that menstruum. M. Taddei, the author of these researches, calls the former *Gliadine*, and the latter *Zimoma.—Giornale di Fisica*, ii. p. 360.

1563. Gluten is an essential ingredient in wheat-flour, and contributes much to its nutritive quality; and gives considerable tenacity to its paste.

1564. A substance, much resembling gluten, has been found in the juices of certain vegetables, especially in those which are milky and coagulable by acids. It is contained in the sap of the houseleek, of the cabbage, and of most of the cruciform plants. Submitted to destructive distillation, it affords ammonia, and is in other respects similar to the animal principle, called albumen; hence it has been termed *vegetable albumen.*

1565. *Caoutchouc* and *Bird-lime* may also be considered as allied to gluten. These substances are insoluble in water and in alcohol, but they are soluble in pure sulphuric ether. Caoutchouc is highly inflammable, burning with a bright flame which throws off much charcoal. When heated it softens, and is in that state soluble in some of the fixed oils. It is said to dissolve easily in oil of cajeput. These solutions are sometimes used as varnishes, but with the exception of that in ether, they remain clammy.

1566. The principles which have now been adverted to, *viz.*, sugar, starch, gum or mucilage, and gluten, constitute the principal nutritive ingredients in most of the esculent vegetables. Wheat grown in this country contains from 18 to 24 *per cent.* of gluten, the remainder being principally starch. The wheat of the south of Europe generally contains a larger quantity of gluten, and is therefore more excellent for the manufacture of macaroni, vermicelli, and other preparations requiring a glutinous paste. The excess of gluten in wheat-flour compared with other grain, renders it peculiarly fit for making bread; for the carbonic acid, extricated during the fermentation of the paste, is retained in consequence of its adhesiveness, and forms a spongy and light loaf.

A hundred parts of barley contain upon an average 80 parts of starch, 6 of gluten, and 7 of sugar, the remaining 7 parts being husk.

From 100 parts of rye Sir Humphry Davy obtained 61 parts of starch and 5 of gluten.

From 100 parts of oats he procured 59 of starch, 6 of gluten, and 2 of sugar.

100 parts of pease afforded about 50 of starch, 3 of sugar, 4 of gluten, and a small portion of extractive matter.

100 parts of potato yield, upon an average, 20 parts of starch; they may be considered in general as containing from one-fourth to one-fifth their weight of nutritive matter.

The turnip, carrot, and parsnip, chiefly contain sugar and mucilage: 1000 parts of common turnips give about 34 of sugar, and 7 of mucilage; 1000 parts of carrots furnish about 95 of sugar, and 3 of mucilage; and the same quantity of parsnips afford 90 of sugar and 9 of mucilage. The loss of weight in the above cases is referable to water, and inert vegetable matter possessed of the properties of woody fibre. (*See the Table at the end of Section* xviii.

SECTION VII. *Extractive Matter and Lignin.*

1567. BY the term *extract*, or *extractive principle*, we mean a substance contained in the greater number of vegetables, and generally forming the principal ingredient in the pharmaceutical preparations called *extracts*. It possesses the following properties. It is soluble in water, and the solution is of a brown colour. It is insoluble in ether, but it is soluble in alcohol containing a small portion of water. By repeated solutions and evaporations it may be rendered scarcely soluble in water. Solutions of chlorine, of many of the acids, and of most of the metallic oxides, occasion precipitates in the aqueous solution of extractive.

1568. The following substances may be considered under this head, though many of them are obviously widely different from extractive matter.

1569. *Ulmin.* This substance was first noticed by Klaproth, spontaneously exuding from the elm. From the observations of Berzelius, it exists in the bark of many other trees, and may be obtained by digestion in alcohol and cold water; the action of hot water afterwards dissolves the ulmin.—THOMSON'S *Annals*, Vol. ii.

Ulmin is of a dark brown colour, with scarcely any taste or smell. It is sparingly soluble in water and in alcohol, but readily soluble in a weak solution of carbonate of potassa. Very few of the metallic salts occasion a precipitate in its solution. The exudation from the elm is generally combined with carbonate of potassa, and is therefore readily soluble in water.

1570. *Polychroite.* This term has been applied to the extract of saffron (*Annales de Chim.* Tom. lxxx.) It is of a deep yellow colour, deliquescent, readily soluble in water and in alcohol, but insoluble in pure sulphuric ether. Exposure to the solar rays soon destroys the colour of its aqueous solution. Sulphuric acid renders it blue, and nitric acid green: solutions of lime and baryta produce yellow and red precipitates: subacetate of lead throws down a deep yellow precipitate, and nitrate of mercury separates a red powder.

1571. *Hematin.* This peculiar substance was first recognised by Chevreul in the colouring matter of *logwood* (*Ann. de Chim.* Tom. lxxxi.) It may be obtained by digesting logwood in water of the temperature of 125°. Filter, evaporate carefully to dryness, and digest the residue for 24 hours in alcohol of the specific gravity of .837. Filter the alcohol; concentrate the solution by evaporation, add a portion of water, evaporate a little further, and set the solution aside: crystals are deposited which, when washed with alcohol and dried, are pure hematin.

Hematin is of a reddish colour; its taste is somewhat bitter, and its aqueous solution is yellow when cold, but orange-red at the temperature of boiling-water. Sulphuric acid added to this solution renders it reddish yellow. The alcalis give it a purplish tint.

1572. *Bitter principle.* By evaporating an infusion of quassia, a substance is obtained of an intensely-bitter taste, and of a brownish-yellow colour, which is readily soluble in water and in alcohol. Nitrate of silver, and acetate of lead, are the only precipitants of its aqueous solution. It is probable that the same substance exists in other bitter vegetables, and Vauquelin has discovered it in the fruit of the *colocynth,* and in the root of *white briony.*—THOMSON's *System,* Vol. iv.

1573. By digesting indigo, silk, and a few other substances in nitric acid, an intensely-bitter matter is formed, called by Welther, the *yellow bitter principle* (*Annales de Chim.* Tom. xxix.) Chevreul has rendered it probable that this is a compound of a peculiar vegetable principle with nitric acid. It is crystallizable, burns like gunpowder, and detonates when struck with a hammer.

1574. *Picrotoxin.* This is a bitter poisonous substance contained in the *Cocculus Indicus.* It may be obtained by the following process:—Add acetate of lead to a decoction of the berries, as long as any precipitate falls: filter, evaporate, and digest the extract in highly-rectified alcohol; evaporate to dryness, and agitate the remaining matter with a little water; the picrotoxin remains in the form of white prismatic crystals of a bitter taste.

1575. Picrotoxin is difficultly soluble in water. Alcohol, of the specific gravity of 810, dissolves one-third its weight. It is soluble in weak solutions of the pure alcalis. It combines with the acids, and forms compounds, some of which are crystallizable, but they require further examination before we can venture to give this substance a place among the narcotic salifiable bases.—BOULLAY, *Journal de Pharmacie,* v.

1576. *Nicotin.* This is a principle existing in tobacco. It was obtained by Vauquelin by the following process (*Ann. de Chim.* lxxi.): Evaporate the expressed juice to one-fourth its bulk; and, when cold, strain it through fine linen; evaporate nearly to dryness; digest the residue in alcohol; filter and evaporate to dryness; dissolve this again in alcohol, and again reduce it to a dry state. Dissolve the residue in water, and saturate the acid which it contains with weak solution of potassa, introduce the whole into a retort, and distil to dryness; re-dissolve, and again distil three or four times successively. The nicotin will thus pass into the receiver, dissolved in water, from which solution it may be obtained by very gradual evaporation.

Nicotin is colourless, acrid, soluble in water and in alcohol, volatile, and highly poisonous.

1577. *Asparagin.*—MM. Vauquelin and Robiquet obtained this substance in a crystalline form by evaporating the juice of asparagus. It has a cool and slightly nauseous taste, and when burned emits acrid vapours, and leaves no traces of alcali.—*Annales de Chimie*, Tom. iv.

1578. *Fungin.* This name has been given by Braconnot to a substance contained in the fleshy part of mushrooms (*Ann. de Chim.* lxxix.) It is insoluble in water and in alcohol, and scarcely acted upon by the alcalis, or by dilute acids. It is the substance which remains after the mushroom has been deprived of every thing soluble in alcohol and in water.

1579. *Inulin.* The roots of elecampane, when boiled in water, furnish a decoction, which, on cooling, deposits a white powder, in many respects resembling starch. It, however, differs in several properties from that principle, and has hence been considered a peculiar vegetable substance.—THOMSON'S *System*, Vol. iv.

1580. *Emetin.* To obtain emetin, digest powdered ipecacuanha in alcohol, filter, evaporate carefully to dryness, and re-dissolve in cold water. To this solution add carbonate of baryta, filter, and again evaporate to dryness; digest this residuum in alcohol, and a solution is obtained, which, by careful evaporation, affords a reddish-brown substance, soluble in alcohol and in water, and precipitable by sub-acetate of lead; its taste is acrid and bitter, and it is highly emetic.—MM. MAGENDIE and PELLETIER, *Annales de Chimie et Physique*, Vol. iv.

1581. *Woody fibre.* The term *lignin* has been applied to the fibrous substance which remains, after digesting wood in water and in alcohol. It is insipid, and, exposed to destructive distillation, affords a considerable quantity of vinegar tainted by empyreumatic oil, and containing a little ammonia. The charcoal which remains, is light, brittle, shining, and easily incinerated. The relative quantity, yielded by different woods, has already been adverted to (386.)

1582. We are indebted to M. Braconnot for some highly-interesting experiments, relating to the action of sulphuric acid on wood (*Ann. de Chim. et Phys.* xii. 172.) In the course of these researches, he triturated 25 parts of hempen cloth with 34 of the acid; it acquired the consistency of mucilage, which, after 24 hours, was almost entirely soluble in water. The diluted liquor was saturated with chalk, filtered, and evaporated to the consistency of sirup; it deposited sulphate of lime, and was then further evaporated to dryness, when a substance, having the characters of gum, was obtained. In another experiment, 24 parts of lignin were reduced to gum by 34 of sulphuric acid; this acid mixture, diluted with water, and boiled for 10 hours, became sweet; the acid was then separated by chalk, and the liquor, on due evaporation, afforded a crystallizable sugar.

Moistened saw-dust, heated in a platinum crucible with its weight of caustic potassa, afforded a matter soluble in water, and which, upon the addition of an acid to neutralize the alcali, yielded a substance having the properties of *ulmin.*

1583. *Suber* or *Cork*. This is a light, soft, elastic, and combustible substance, burning with a bright flame and leaving a bulky charcoal. Its principal peculiarity is, that by digestion in nitric acid, it is converted into an orange-coloured mass, which furnishes to water a peculiar acid matter, which has been termed *suberic acid.* Chevreul has found in it resin, oil, and a peculiar matter which he calls *Cerin.*—See WAX (1609.)

1584. *Cotton* is a downy substance found in the seed-pods of the different species of *gossypium.* It is insoluble in water and in dilute alcaline and acid solutions. It combines with several of the metallic oxides, which are therefore used as intermedes, or *mordants*, in the art of dyeing. Acetate of alumina is principally employed for this purpose.

1585. *Medullin* is a term given by Dr. John to the pith of the sun-flower and some other plants; it is insipid, inodorous, insoluble in water and alcohol, and affords oxalic acid when treated by nitric acid; submitted to destructive distillation, the products abound in ammonia.

SECTION VIII. *Tannin.*

1586. TANNIN, or the astringent principle, is contained in many vegetables. It may be procured by digesting bruised gall-nuts, grape-seeds, oak-bark, or catechu, in a small quantity of cold water. The solution affords, when evaporated, a substance of a brownish-yellow colour, extremely astringent, and soluble in water and in alcohol.

The purest form of tannin appears to be that derived from bruised grape-seeds, but even here it is combined with other substances, from which it is perhaps scarcely separable, and among the numerous processes which have been devised for procuring pure tannin, there is none that answers the intended purpose. I have never been able to obtain it of greater apparent purity than by digesting powdered catechu in water at 33° or 34°, filtering and boiling the solution, which, on cooling, becomes slightly turbid, and is to be filtered again, and evaporated to dryness; cold water, applied as before, extracts nearly pure tannin.

1587. The most distinctive character of tannin is that of affording an insoluble precipitate when added to a solution of isinglass, or any other animal jelly. Upon this property the art of tanning depends, for which oak-bark is generally employed; the barks, however, of many other trees may occasionally be substituted. The following Table, drawn up by Sir Humphry Davy, exhibits the average quantity of tan contained in 480 lbs. of different barks—*Agricultural Chemistry*, 4to. p. 79.

	lbs.
Average of entire bark of middle-sized Oak, cut in spring	29
———— of Spanish Chestnut	21
———— of Leicester Willow, large size	33
———— of Elm	13
———— of Common Willow, large	11
———— of Ash	16
———— of Beech	10
———— of Horse Chestnut	9
———— of Sycamore	11
———— of Lombardy Poplar	15
———— of Birch	8
———— of Hazel	14
———— of Black Thorn	16
———— of Coppice Oak	32
———— of Oak cut in autumn	21
———— of Larch cut in autumn	8
White interior cortical layers of Oak-bark	72

1588. Tan forms a precipitate with solution of starch, with gluten and albumen, and with many of the metallic oxides. An account of the precipitates formed in metallic solutions by infusion of galls, will be found under the article *Gallic Acid* (1771) but these precipitates are very complex, and vary in composition.

1589. If the solution of tan, obtained as above-described from catechu, be added to acetate of lead, an insoluble *tannate of lead* falls, composed, according to Berzelius, of 100 tannin + 52 oxide of lead. Now, if we suppose that tannin forms definite compounds with the metallic oxides, in the manner of a vegetable acid, the number 200 will be its representative, as deduced from the above datum.

1590. Mr. Hatchett has shown that tan may be formed artificially by digesting charcoal in dilute nitric acid during several days; it is at length dissolved, and a reddish brown liquor is obtained, which furnishes, by careful evaporation, a brown glossy substance, amounting to about 120 parts from 100 of charcoal.

This *artificial tannin* appears to differ in one circumstance only from natural tannin, which is, that it resists the action of nitric acid, by which all the varieties of natural tannin are decomposed, though some are more capable of resisting its action than others.

Artificial tannin has a bitterish astringent taste, is soluble in water and alcohol, and forms an insoluble precipitate in solutions of animal gelatine, the precipitate consisting, according to Mr. Hatchett, of

36	Tannin.
64	Gelatine.
100	

Muriatic and sulphuric acids occasion brown precipitates, in solution of artificial tan, which are soluble in hot water. It combines with the alcalis, and forms a precipitate of difficult solubility in aqueous solutions of lime, baryta, and strontia, and in most metallic solutions; these precipitates are of a brown colour.

1591. A variety of artificial tan is formed by digesting camphor and resins in sulphuric acid, till the liquor becomes black, and on being poured into water, deposits a black powder, which, by digestion in alcohol, furnishes a brown matter, soluble in water, and forming an insoluble precipitate with gelatine.—HATCHETT, *Phil. Trans.* 1805, 1806.

SECTION IX. *Colouring Matter.*

1592. THE colouring matter of vegetables appears to reside in several of their principles, and is therefore very differently acted on by solvents. Its extraction, and transfer to different substances, constitutes the *art of Dyeing*.

1593. Different materials not only possess very different attractions for dye stuffs, but they absorb the colouring matter in very different proportions. Wool appears in this respect to have the strongest attraction for colouring substances: silk comes next to it; then cotton; and, lastly, hemp and flax.

1594. Colours have been divided by Dr. Bancroft, in his work on *Permanent Colours*, into *substantive* and *adjective*. The former communicate colour without the intervention of any other substance. They have an attraction for the fibre of cloth or linen, and are permanently retained. The latter require the intervention of some body, possessed of a joint attraction for the colouring material and stuff to be dyed. The substance capable of thus fixing the colour, has been called a *basis*, or *mordant*.

1595. The mordants most frequently employed are *acetate of salumina*, *ulphate* or *acetate of iron*, and *muriate of tin*. The substance to be dyed is first impregnated with the mordant, and then passed through a solution of the colouring matter, which is thus fixed in the fibre, and its tint is either modified or exalted by the operation.

The following are the modes of producing some of the principal colours:

1596. *Black* is produced by astringents and salts of iron, and if intended to be deep and perfect, the cloth should previously be dyed blue with indigo. The stuff is first soaked in a bath of galls, then rinced, and passed repeatedly through a solution of sulphate of iron in infusion of logwood; exposure to air deepens the colour, which at first has a purplish tint. Logwood tends considerably to improve the black, and prevents its acquiring a rusty or brown hue. Sometimes madder is used for the same purpose. Silk is dyed black nearly in the same way, but it requires a much larger relative proportion of galls, and the operation must be frequently repeated. It is difficult to give a good and permanent black to calico; in this process, acetate of iron, galls, and madder are generally used, and the colour is rendered more durable by previously steeping the goods in a weak solution of glue.

Grey is produced by the same operations as black, but the materials are used in a very dilute state.

1597. *Blue* is chiefly derived from *indigo,* a substance produced by fermenting the leaves of several species of the *indigofera,* a plant abundantly cultivated in South America and in the East Indies.

1598. *Indigo* is a substance of a deep blue colour, containing about 50 *per cent.* of pure colouring matter, which is perfectly insoluble in water; when heated it sublimes in the form of a blue smoke, which, on condensation, forms acicular crystals. It is soluble in concentrated sulphuric acid. This solution is usually called *Saxon* or *liquid blue,* and is used as a substantive colour for dyeing cloth and silk. Substances which powerfully attract oxygen render indigo green, and by exposure to air, it again acquires a blue colour. In this green state indigo is soluble in the alcalis, and the solution is commonly employed for dyeing calico. A bath for this purpose may be made by mixing one part of indigo, two parts of sulphate of iron, and two of lime, in a sufficient quantity of water: in this case the sulphate of iron is decomposed by a portion of the lime. The protoxide of iron thus produced becomes peroxidized at the expense of the indigo, which is rendered green and soluble in the alcaline liquor; cotton steeped in this solution acquires a green colour, which by exposure to air, and washing in water acidulated with sulphuric acid, becomes a permanent blue.

A little iron or zinc thrown into diluted sulphate of indigo, changes or destroys the colour in consequence of the evolution of hydrogen; the colour is also quickly impaired and destroyed by chlorine.

1599. The analysis of indigo, to ascertain the proportion of colouring matter, which varies much in different samples, may be performed by the successive action of water, alcohol, and muriatic acid (CHEVREUL, *Ann. de Chim.* lxvi. 20.) 100 parts of Guatimala indigo, thus treated, afforded

To Water	Green matter combined with ammonia	12
	Deoxidized indigo	
	Extract	
	Gum	
To Alcohol	Green matter	30
	Resin	
	A trace of indigo	
To Muriatic Acid	Red resin	6
	Carbonate of lime	2
	Oxide of Iron	2
	Alumina	
Residue	Silica	3
	Pure indigo	45
		100

1600. The action of nitric acid on indigo has been particularly examined by Mr. HATCHETT (*Additional Experiments on Artificial Tannin, Phil. Trans.* 1805.) This acid, diluted with about two parts of water, produces much effervescence when poured on powdered indigo, and gradually dissolves it; the solution, evaporated to dryness, leaves a yellow residue, soluble in water, of an intensely bitter taste, and composed partly of artificial tannin, and partly of a peculiar *bitter principle* combined with ammonia.

1601. *Yellow*. There are several dye stuffs employed in the production of yellows. A decoction of *Weld* (*Reseda Luteola*,) with an aluminous mordant gives a good yellow, which is rendered more brilliant by tartar, and by permuriate of tin.

The bark of the American oak (*Quercus Nigra*,) or *Quercitron bark*, also furnishes excellent yellows; it was first introduced into England by Dr. Bancroft, who has fully and philosophically detailed its various applications, (*Experimental Researches concerning the Philosophy of Permanent Colours*, &c., London, 1813.) The salts of alumina and of tin are the principal mordants employed both with wool and cotton.

Fustic wood, *sumach*, and *dyers' broom*, are also occasionally employed as sources of yellow colours.

1602. *Reds* are chiefly produced from *madder*, the prepared root of the *Rubia Tinctorum*. The colouring matter is fixed by an aluminous mordant, assisted by galls, but the process is very complex and circuitous. In Dr. Bancroft's work above quoted (Vol. ii.) are full details upon this subject; and a perspicuous abstract of them will be found in AIKIN'S *Dictionary*, Art. DYEING.

Brazil wood, *safflower*, and *logwood* are occasionally employed as red or pink dye stuffs, but they only give fugitive colours.

1603. *Scarlet* is produced exclusively with the colouring matter of the *cochineal*, a small insect brought from Mexico, where it is found upon different species of the *Opuntia*. The nature of this colouring matter has been investigated by MM. Pelletier and Caventou; it is united in the insect with a peculiar animal matter, fat, and some saline substances; they separated it by exposing a strong alcoholic tincture of cochineal to spontaneous evaporation; it deposited a crystalline matter, which was re-dissolved in alcohol and the solution mixed with its bulk of sulphuric ether; this caused it in a few days to deposit the pure colouring principle, which they call *Carminium*: Dr. John has proposed for it the term *Coccinellin*. This substance is fusible at about 120°, very soluble in water, less so in alcohol, and insoluble in ether; the acids change its colour from purple to pale red or yellow: the alcalis render it violet; and its colour is impaired by most saline solutions. It readily combines with alumina, forming a beautiful *lake* or *carmine*.

The colouring matter of cochineal is fixed upon wool by nitromuriate of tin and tartar, by which scarlets are produced, and alum changes the scarlet to crimson. Cotton and linen are very rarely dyed with cochineal, for, independent of its great expense, the colours are little superior to those given by madder.

1604. *Buff* and *Fawn colour* are produced in a variety of ways. *Walnut-husks* and *Sumach*, with alum mordants, give durable colours of this description, which are rendered *Drab*, or *Grey*, by a very little iron.

1605. *Green* is obtained on woollen cloth, by passing it through the green indigo vat, and then dyeing it as for simple yellows, the relative proportion of the blue and yellow being adjusted to the intended intensity of the green. Silk is first dyed yellow, and afterwards blued with indigo. *Saxon green* is done by dyeing yellow upon a Saxon blue ground. A solution of verdigris in vinegar is sometimes used to produce a delicate green: pearl-ash is added before it is used, and the cotton previously impregnated with the alum mordant, is then passed through the mixture.

Besides the above, an infinite variety of *compound colours* are formed, by mixtures of the simpler tints, and of the mordants; but as my object is merely to give a general idea of the principles of the art of dyeing, I must refer the reader for practical details to the works expressly upon the subject, and more especially to Dr. Bancroft's *Treatise* already quoted.

1606. *Calico-printing* is a more refined and difficult branch of the art of dyeing. In this process adjective colours are almost always employed. The mordants, the principal of which are acetate of alumina, and acetate of iron, are first applied to the calico by means of wooden blocks or copper plates, upon which the requisite patterns are engraved. The stuff is then passed through the colouring bath, and afterwards exposed on the bleaching ground, or washed. The colour flies from those parts which have not received the mordant, and is permanently retained on those parts only, to which the basis has been applied: variety of colours is produced by employing various mordants, and different colouring materials.

White spots upon a dark ground are sometimes produced by covering the parts with wax, pipe-clay, or other materials, which prevent the contact of the colour; or citric acid, thickened with gum, is applied like a mordant with the block or plate, which prevents the retention of the colour. Sometimes the colour is discharged in places by the application of chlorine.

SECTION X. *Wax.*

1607. THIS principle exists in many plants; it may be obtained by bruising and boiling them in water: the wax separates and concretes on cooling.

The berries of the *Myrica cerifera*, and the leaves and stem of the *Ceroxylon* afford considerable quantities of wax by this process (BOSTOCK, NICHOLSON'S *Journal*, Vol. iv., BRANDE. *Phil. Trans.* 1811.) The glossy varnish upon the upper surface of the leaves of many trees is of a similar nature, and though there are shades of difference, these varieties of wax possess the essential properties of that formed by the bee.

1608. Pure wax is colourless and insipid; its specific gravity is about .96: it is insoluble in water, and fusible at a temperature of about 150°; at a higher temperature it is converted into vapour, and at a red heat it burns in the contact of air with a bright flame. It is sparingly soluble in boiling alcohol and ether, and is deposited as the solutions cool. The fixed oils, when assisted by heat, readily dissolve it, and form a compound of variable consistency, which is the basis of *cerates* and *ointments*. Some of the volatile oils also dissolve wax, when aided by heat. It is soluble in the fixed alcalis, forming soapy compounds; but the acids scarcely act upon it; hence the advantage of *wax-lute*, for the retention of corrosive vapours.

1609. When bees'-wax, or myrtle-wax, are digested in boiling alcohol, they afford, according to Dr. John, a soluble and insoluble portion; he has called the former *cerin*, the latter *myricin*. Cerin is insoluble in water and in cold alcohol and ether, but dissolves in those liquids when heated. Myricin is insoluble, under all circumstances, in alcohol and ether.

The term *cerine* has been applied by Chevreul to a principle resembling wax, which he separated from cork; it is less fusible than wax, more soluble in alcohol, and partly converted into oxalic acid, by the action of nitric acid (1583).

1610. According to Gay-Lussac and Thenard, 100 parts of wax consist of 81.79 carbon, 6.30 of the elements of water, and 11.91 of excess of hydrogen; these numbers may be considered as equivalent to

1	Proportional of oxygen........		=	7.5 ..	5.5
20	,, ,, carbon	5.7 × 20	=	114.0 ..	81.5
18	,, ,, hydrogen	1. × 18	=	18. ..	13.0
				139.5	100.0

SECTION XI. *Fixed Oil.*

1611. FIXED OIL is generally obtained by pressure from certain seeds, such as the almond, linseed, and many others, and from the olive. The specific gravity of the fixed oils, is usually a little below that of water. They are viscid; insipid, or nearly so; and generally congeal at a temperature not so low as that required to freeze water. A few of them are solid at the ordinary temperature, and have been called *vegetable butters.* They are insoluble in water, but by the aid of mucilage may be diffused through it, forming *emulsions.* They are for the most part sparingly soluble in alcohol and ether, though castor-oil dissolves in any quantity in those fluids.—BRANDE, *Phil. Trans.* 1811.

1612. Olive oil is sometimes adulterated with that of certain seeds, which may be detected by the action of nitrate of mercury. For this purpose, 6 parts of mercury are dissolved without heat in 7.5 parts of nitric acid, specific gravity 1.36; this solution, shaken with olive oil, becomes solid in a few hours; but if sophisticated with oil of grains, it does not solidify it.

1613. If oil, which has been congealed by cold, be submitted to pressure between folds of bibulous paper, a dry, concrete, fatty matter is obtained, which Chevreul has called *Stearine:* the paper absorbs a fluid matter, which does not congeal at a much lower temperature, and which, though it does not become rancid, acquires viscidity by exposure to air. This fluid part he has called *Elaine.* The relative proportions of these principles differ in the different oils.—*Annales de Chimie*, Tom. xciii. xciv.—See *Animal Oils.*

1614. These oils cannot be volatilized without decomposition, which takes place at a temperature of about 600°, and water is copiously formed, attended by the separation of carbonaceous matter, which causes the oil to blacken and grow thick; a portion of acetic acid is also at the same time formed. If the vapour be collected it is found acrid, sour, and empyreumatic; it was formerly employed in pharmacy, under the name of *philosophers' oil*, and as it was often obtained by steeping a brick in oil, and submitting it to distillation, it was also called *oil of bricks*. Passed through a red-hot tube, the fixed oils furnish a very large proportion of carburetted hydrogen gas (435); and when burned in the wicks of lamps they suffer a similar decomposition, and water and carbonic acid are the products of their combustion.

1615. The greater number of the fixed oils undergo little other change by exposure to air than that of becoming somewhat more viscid, and acquiring a degree of rancidity. In this state they contain free acid, and redden vegetable blues. Some few, such as linseed and nut-oil, and the oils of the poppy and hempseed, become covered with a pellicle, and when thinly spread upon a surface, instead of remaining greasy, become hard and resinous; these are termed *drying oils*, and their drying quality is much improved by boiling them upon a small quantity of litharge,

1616. The drying oils, and especially nut-oil, form the basis of *printers' ink*, the history of which will be found in LEWIS'S *Phil. Commerce of the Arts*. The oil is heated and set fire to, and after having been suffered to burn for half an hour is extinguished, and boiled till it acquires a due consistency; in this state it is called *Varnish*, and is viscid, tenacious, and easily miscible with fresh oil, or with oil of turpentine, by which it is properly thinned, and afterwards mixed with about one-eighth part of lamp-black.

1617. The alcalis readily combine with the fixed oils, and form white compounds called *Soap*. Of these the most important is the *soap of soda*, which is thus made: Five parts of barilla are mixed with one of lime and a proper quantity of water. In this way a *ley*, or solution of caustic soda, is obtained, which is boiled in an iron pot with six parts of oil till the soap separates, which is accelerated by the addition of common salt; it is then suffered more perfectly to congeal, and in a few days becomes hard enough to cut into forms (AIKIN's *Dictionary*, Art. SOAP.) The best soaps are made with olive oil and soda; in this country animal fat is usually employed for the common soaps, to which resin and some other substances are occasionally added. *Soft Soap* is a compound of potassa with some of the common oils; even fish oil is often used.

Soap furnishes a milky solution with water. It dissolves in alcohol, and the solution, if concentrated, is of a gelatinous consistency. By carefully distilling off the alcohol, a *transparent soap* is obtained.

The acids and the greater number of salts decompose soap, forming in most cases a compound of difficult solubility; hence *hard waters* are unfit for washing, in consequence of containing sulphate of lime; hence also the alcoholic solution of soap is useful as a test for ascertaining the fitness of water for this purpose, which, if it becomes very turbid, cannot in general be used for washing.

When soaps are decomposed by the acids, the oil which they contain is found to have undergone a change, the history of which will be noticed under the head of *animal oils.*

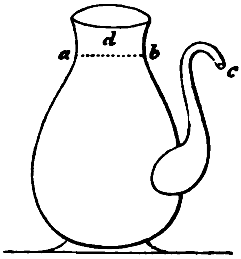
1618. The fixed oils readily combine with oxide of lead, when aided by heat, forming the compound usually termed *plaster ;* with the oxides of mercury and bismuth they produce very similar combinations, and are also capable of dissolving white arsenic in large proportion.

1619. The ultimate components of olive oil, as given by Gay-Lussac and Thenard, are

77.21	carbon.
9.43	oxygen.
13.36	hydrogen.
100.	

SECTION XII. *Volatile Oils.*

1620. THESE oils are generally obtained by distilling the plants which afford them with water in common stills ; the water and oil pass over together, and are collected in the *Italian recipient* shown in the following cut, in which the water having reached the level *a b*, runs off by the pipe *c*, and the oil being generally lighter than water, floats upon its surface in the space *d*. The whole contents of the recipient are then poured into a funnel, the tube of which is closed with the finger, and when the oil has collected upon the surface, the water is suffered to run from it, and the oil transferred into a bottle. The distilled water being saturated with the oil, should be retained for a repetition of the distillation. The produce of oil is sometimes increased, by adding salt to the water in the still, so as to elevate its boiling point a few degrees.



Some of the volatile oils are obtained by expression, such as those of *lemon*, *orange*, and *bergamot*, which are contained in distinct vesicles in the rind of those fruits.

1621. The volatile oils vary considerably in specific gravity, as shown by the following Table:

Oil of	Sassafras	1.094
,,	Cinnamon	1.035
,,	Cloves	1.034
,,	Fennel	997
,,	Dill	994
,,	Penny-royal	978
,,	Cummin	975

Oil of	Mint	975
„	Nutmegs	948
„	Tansy	946
„	Caraway	940
„	Origanum	940
„	Spike	936
„	Rosemary	934
„	Juniper	911
„	Oranges	888
„	Turpentine	792

1622. The volatile oils have a penetrating odour and taste, and are generally of a yellowish colour; they are for the most part very soluble in alcohol, and very sparingly soluble in water; these solutions constitute *perfumed essences* and *distilled waters.* The latter are principally employed in pharmacy, and the former as perfumes.

When pure they pass into vapour at a temperature somewhat above that of 212°, but when distilled with water, they pass over at its boiling point. They are very inflammable, and water and carbonic acid are the results of their perfect combustion. As many of these oils bear a very high price, they are not unfrequently adulterated with alcohol and fixed oils. The former addition is rendered evident by the action of water; the latter, by the greasy spot which they leave on paper, and which does not evaporate when gently heated.

1623. The volatile oils absorb oxygen, when long exposed to it, and become thick and resinous. They also absorb chlorine. Nitric and sulphuric acids rapidly decompose the volatile oils: a mixture of four parts of nitric, and one of sulphuric acid, poured into a small quantity of oil of turpentine, produces instant inflammation, and muriatic acid is produced, along with a peculiar substance, in some cases not unlike camphor. Iodine produces changes somewhat analogous. Muriatic acid combines with several of them, and forms a crystallizable compound which has been compared to camphor (1632).

1624. The relative quantity of essential oils, furnished from different materials, is liable to much variation; the following are the products of 1 cwt. of the different vegetable substances:

	Ounces.
Juniper-berries (common)	4 to 5
Ditto (fine Italian)	7 to 8
Aniseed (common)	32 to 36
Ditto (finest)	36 to 38

		lbs.	oz.		lbs.	oz.
Caraways	from	3	12	to	4	12
Dill-seed	from	2		to	2	6
Cloves	from	18		to	20	
Pimento	from	2		to	3	4
Fennel-seed					2	
Leaves of the *Juniperus Sabina*						14

SECTION XIII. *Camphor.*

1625. THIS substance in many respects resembles the essential oils; like them it is volatile, inflammable, soluble in alcohol, and sparingly soluble in water.

In its ordinary state it is white, semi-transparent, and concrete. Its specific gravity .98. It fuses at about

300°, in close vessels. It dissolves in the fixed and volatile oils. It is scarcely acted upon by the alcalis; some of the acids dissolve, others decompose it.—HATCHETT, *Phil. Trans.* 1805. CHEVREUL, *Annales de Chimie*, lxxiii.

If mixed with bole or powdered clay, and repeatedly distilled, it is almost entirely converted into a liquid, having the characters of essential oil.

The camphor of commerce is obtained from the *Laurus camphora*, and comes chiefly from Japan. It is originally separated by distillation, and subsequently purified in Europe in a subliming vessel somewhat of the shape of a turnip, from which the cakes of camphor derive their form.

1626. When camphor is repeatedly distilled with nitric acid it is converted into *camphoric acid.* For this purpose four ounces of camphor, reduced to powder by triturating it with a few drops of spirit of wine, may be introduced into a two-quart tubulated retort, placed in a sand heat; pour upon it 30 ounces of common nitric acid, and proceed to slow distillation. When two thirds of the acid have passed over, return it into the retort and distil as before, repeating the operation twice more; after which. as the liquor cools, a quantity of crystals of camphoric acid are deposited, which are to be washed and dried. This acid assumes the form of plumose crystals, soluble in about 100 parts of water at 60°, and in rather more than 1 part of alcohol. Its taste is acid, and somewhat acrid, and it has an aromatic odour. Exposed to heat it sublimes unaltered. It combines with the salifiable bases, constituting a class of salt called *Camphorates.*

1627. *Camphorate of ammonia* is with difficulty crystallized; it is sparingly soluble in water, but more copiously in alcohol.

1628. *Camphorate of Potassa* forms hexagonal crystals, soluble in about 100 parts of water at 60°, and in 25 parts at 212°. Its alcoholic solution burns with a blue flame.

1629. *Camphorate of Soda* is possessed nearly of the same properties as the preceding.

1630. *Camphorate of Lime* is nearly insoluble in water and alcohol.

1631. *Camphorate of Baryta* forms difficultly soluble lamellar crystals.—BOUILLON LAGRANGE, *Annales de Chimie*, xxvii.

1632. When a current of muriatic acid gas is passed through oil of turpentine, it deposits a concrete substance, which has been called *artificial camphor*, and the weight of which amounts to about one-half of the oil employed. When purified by sublimation with a little quicklime, it is rendered pure and white. It is lighter than water, sublimes without decomposition, burns like camphor, and in smell resembles a mixture of camphor and turpentine (THENARD, *Mémoires d'Arcueil*, Tom. ii.) By the action of zinc it affords chloride of zinc, and the oil is evolved little altered.

1633. Camphor dissolves in sulphuric acid, forming a brown solution, from which it is at first precipitated, unaltered, by water. Sulphurous acid is afterwards evolved, the solution becomes black and thick, and, after some days, affords a brown coagulum on the addition of water, and smells fragrant and peculiar. On distilling the diluted liquor, water and a yellow oil pass over, a little sulphurous acid is then disengaged, and a black matter remains in the retort, which, when digested in alcohol, affords a portion of soluble matter having some of the properties of artificial tannin.—HATCHETT, *Phil. Trans.* 1805.

SECTION XIV. *Resins.*

1634. RESINS are substances which exude from many trees, either from natural fissures or artificial wounds. Common resin is obtained by distilling the exudation of different species of fir: *oil of turpentine* passes over, and the resin remains behind. It may be taken as a perfect example of resin, and is possessed of the following properties: It is solid, brittle, a little heavier than water, and acquires negative electricity when rubbed. It has scarcely any taste or smell; is insoluble in water; readily soluble in alcohol, which takes up about one-third its weight, and becomes milky upon the addition of water. Resin is soluble in the caustic alcalis, the solution is saponaceous, and when mixed with an acid, the resin separates, scarcely altered in its properties. Nitric, muriatic, and acetic acids dissolve it without much change*.

---

* The properties of the resins have been very ably investigated by Mr. Hatchett, the details of whose researches will be found in his communications to the Royal Society, printed in the *Philosophical Transactions* for 1804, 1805, 1806.

1635. A few of the resins derive odour from containing essential oil; some afford benzoic acid when heated, and these have been termed *balsams; copal, mastick*, and a few others, are very difficultly soluble in alcohol, and contain a substance somewhat analogous to caoutchouc. *Guaiacum* is characterized by the singular changes of colour, which its alcoholic solution suffers when exposed to the action of nitric acid,—*Phil. Trans.* 1811.

Guaiacum is also rendered blue by the gluten of wheat, but its colour is not changed by starch; the intensity of the blue colour is said to be proportional to the quantity of gluten present in flour.—TADDEI, *Giornale di Fisica*, i. 168. *Quarterly Journal*, viii. 376.

1636. *Lac* is a substance formed by an insect, and deposited on different species of trees, chiefly in the East Indies. The various kinds of lac distinguished in commerce, are *stick lac*, which is the substance in its natural state, investing the small twigs of the tree: *seed-lac*, which is the same broken off; and which, when melted, is called *shell-lac*. These substances have been examined by Mr. Hatchett [*]. The following table exhibits their component parts.—*Phil. Trans.* 1804.

	Stick-Lac.	Seed-Lac.	Shell-Lac.
Resin	68	88.5	90.9
Colouring matter	10	2.5	0.5
Wax	6	4.5	4.0
Gluten	5.5	2.0	2.8
Foreign bodies	6.5	——	——
Loss	4.0	2.5	1.8
	100	100	100

---

[*] Dr. Pearson obtained a peculiar acid from a substance called *white lac*, from Madras. He has called it *laccic acid.*—*Phil. Trans.* 1794.

1637. Dr. John has announced the presence of a peculiar acid in stick-lac, which he has called *Laccic Acid.* The lac was digested in water, the solution evaporated, and the residue digested in alcohol: the alcoholic solution was evaporated to dryness, and its residue digested in ether. The evaporation of the etheric solution leaves a yellow matter, which, being again dissolved in alcohol, and the solution mixed with water, deposits a little resin, and leaves laccic acid in solution, which, upon the addition of acetate of lead, gives a precipitate of *laccate of lead*; the latter compound, by cautious decomposition by sulphuric acid, affords the laccic acid.

1638. Laccic acid is crystallizable, of a yellow colour, a sour taste, and soluble in water, alcohol, and ether. With potassa, soda, and lime, it forms deliquescent soluble salts; with lead and mercury it produces white insoluble compounds; it occasions no precipitate in the nitrates of baryta and silver.—THOMSON'S *System*, ii. 177.

1639. *Gum Resins* are natural combinations of gum and resin, they are consequently only partially soluble in water and in alcohol; they readily dissolve in alcaline solutions when assisted by heat; and the acids act upon them nearly as upon the resins. *Ammoniacum*, *gamboge*, *assafœtida*, and *olibanum*, may be taken as examples of gum resins.

1640. *Amber* is a substance which, in some of its properties, resembles resin; it is, however, very sparingly soluble in alcohol, and difficultly soluble in the alcalis. When submitted to distillation, it furnishes an acid sublimate, which has received the name of *succinic acid*, and which, when purified by repeated solutions and crystallization, possesses the following properties:—

1641. It forms yellowish prismatic crystals soluble in 24 parts of water at 60°, and of a slightly acid and nauseous taste; it is fusible and volatile when heated. 10 lbs. of amber yield about 3 ounces of purified succinic acid. Along with the succinic acid there distils over a quantity of volatile oil, of a light brown colour, used in pharmacy under the name of *Oil of Amber*, and amounting to about one-third in weight of the amber used.

1642. *Succinate of Ammonia* forms acicular crystals, which sublime when cautiously heated. Its solution has been used as a test for iron, the peroxide of which it throws down from its neutral solutions in the form of a reddish brown precipitate.

1643. *Succinate of Potassa* is a very soluble deliquescent salt, crystallizable with difficulty in small prisms.

1644. *Succinate of Soda* forms transparent four and six-sided prisms, considerably less soluble than the preceding, and permanent in the air.

1645. *Succinate of Lime* forms permanent and difficultly soluble crystals.

1646. *Succinate of Baryta* is formed by adding succinate of ammonia to muriate of baryta. A portion is thrown down in a pulverulent form, and a part in small crystalline grains.—BERGMAN.

1647. *Succinate of Strontia* may be formed as the preceding, and presents similar properties. It burns with a fine red flame.

1648. *Succinate of Magnesia* is deliquescent and uncrystallizable.

1649. *Succinate of Manganese* has been examined by Dr. John (GEHLEN's *Journal*, iv.) It is crystallizable, and of a slight red tinge; it consists of 30.27 protoxide of manganese + 69.73 acid and water. The theoretical constitution of succinate of manganese is

46.7 acid.
36 oxide.

so that the above salt is probably a bi-succinate.

1650. *Succinate of Iron.* The *protosuccinate* is crystallizable and soluble; the *persuccinate* is insoluble, and is thrown down in the form of a brownish red flaky precipitate from solutions of the peroxide of iron. This salt has been proposed as a means of separating iron in analysis, but is quite inapplicable in the greater number of cases.

1651. *Succinate of Zinc* furnishes long slender crystals, which have not been examined.

1652. *Succinate of Tin.* The succinic acid dissolves protoxide of tin, and forms with it thin broad transparent crystals.

1653. *Succinate of Copper.* There appear to be two varieties of this salt, a super-succinate and a sub-succinate. (For details respecting several of the succinates, the reader is referred to WENZEL's *Lehre der Verwandtschaft der Körper*; and to GREN, *Handbuch*, iii. 19.)

1654. *Succinate of Lead.* When succinic acid, or succinate of ammonia, is added to acetate of lead, a white precipitate of succinate of lead falls, composed, according to Berzelius, of

Succinic acid	30.9
Protoxide of lead	69.1
	100.

These numbers give 46.7 as the representative of succinic acid, and, considering the succinate of lead as composed of 1 proportional of each of its components, it will consist of

Succinic acid............	46.7
Protoxide of lead	104.5
	151.2

The remaining succinates are not of sufficient importance to require enumeration.

1655. The resins are applied to a variety of useful purposes; and dissolved in alcohol and oils they constitute the different *varnishes.*

BIBL. CODR. COLL. OMN. ANIM. OXON.

SECTION XV. *Narcotic Principles.*

1656. THE substance to which the narcotic power of opium is referable, has been examined with much attention by M. Serteurner; he has termed it *morphia.*

Morphia may be obtained from powdered opium by triturating it into a paste with dilute acetic acid: pour caustic ammonia into the filtered solution, and evaporate; during the evaporation a brownish substance separates, which, by digestion in a small quantity of cold alcohol, becomes nearly colourless, and is pure morphia.

Morphia is sparingly soluble in water, but readily soluble in alcohol and in ether, from which it may be obtained in quadrangular and octoëdral crystals. It is highly poisonous and narcotic, even when administered in very small doses; it is fusible and combustible.

Morphia appears in some respects to possess the properties of an alcali; it reddens turmeric, and forms crystallizable compounds with the acids.

1657. *Nitrate of Morphia* forms acicular crystals, soluble in 1.5 of water, at 60°.

1658. *Sulphate of Morphia* crystallizes in prisms, soluble in two parts of water, at 60°, and composed, according to Pelletier and Caventou (*Journal de Pharmacie*, v.) of

11	Sulphuric acid.
89	Morphia.
100	

1659. *Carbonate of Morphia* forms prismatic crystals, soluble in 4 parts of water, at 60°, and containing, according to Choulant (*Annals of Phil.* xiii.)

28	Carbonic acid.
22	Morphia.
50	Water.
100	

These salts have a bitter taste, and are decomposed by ammonia; they have, however, been but imperfectly examined.

1660. In opium morphia is said to be combined with a peculiar acid, which has been called the *meconic acid*, and this combination is decomposed by the action of ammonia in the preparation of morphia.

The following process is said to afford pure meconic acid: Boil infusion of opium with magnesia, and digest the precipitate in alcohol; *meconiate of magnesia* remains: dissolve this in dilute sulphuric acid, and add muriate of baryta, a precipitate falls, composed of sulphate and *meconiate of baryta;* digest this in dilute sulphuric acid, which decomposes the meconiate; filter and evaporate, till brown crystals of impure meconic acid are deposited; dry these crystals, and then heat them carefully in a retort, to sublime the meconic acid. White crystals are thus obtained, which fuse at 250°, and sublime without decomposition; they are sour, and very soluble in water and alcohol.

1661. *Meconiate of Ammonia* forms stellated crystals, soluble in 1.5 parts of water, at 60°, and composed, according to Choulant, of

42	Ammonia.
40	Meconic acid.
18	Water.
100	

1662. *Meconiate of Potassa* forms four-sided tables, soluble in 2 parts of water at 60°, and composed of

60	Potassa.
27	Meconic acid.
13	Water.
100	

1663. *Meconiate of Soda* forms efflorescent prismatic crystals, soluble in 5 parts of water at 60°, and composed of

40	Soda.
32	Meconic acid.
28	Water.
100	

1664. *Meconiate of Lime* affords prismatic crystals, soluble in 8 parts of water at 60°, and consisting of

42	Lime.
34	Acid.
24	Water.
100	

The equivalent number of meconic acid, deduced from the above analyses, by Choulant, will be about 21.

1665. MM. Pelletier and Caventou, in analyzing the *bean of St. Ignatius* (*Strychnos Ignatia*), and the *vomica nut* (*Strychnos nux vomica*), discovered in them a peculiar principle, which they have termed *Strychnine*, and which, like morphia, posseses alcaline properties. The following is their process for obtaining it: Digest the raspings of the bean in sulphuric ether, which separates a green oily fluid; pour this off, and treat the residuum with alcohol; filter the latter solution when cold, and evaporate; it leaves a brown bitter substance, soluble in water and alcohol; to its strong aqueous solution add a solution of potassa, which causes a precipitate, which, when washed with a little cold water, is white, crystalline, and very bitter. If not quite pure, it may be rendered so by solution in acetic acid, and precipitation by potassa.

1666. Strychnine, or *Strychnia*, is nearly insoluble in water; it dissolves in alcohol, and the solutions are intensely bitter and poisonous. It reproduces the blue of vegetable colours reddened by acids. It crystallizes in small quadrangular prisms; it has no smell, and is neither fusible nor volatile, but is decomposed at about 600°. into products consisting of oxygen, hydrogen, and carbon.

1667. The *Salts of Strychnia* are decomposed by potassa, soda, ammonia, baryta, strontia, and magnesia, the base being thrown down; most of the other metallic salts are decomposed by strychnia, and with some it forms triple salts.

1668. *Sulphate of Strychnia* forms cubic crystals, soluble in about 10 parts of water at 60°; its taste is bitter, and it is decomposed by the alcalis. It consists of

Sulphuric acid	9.5
Strychnia	90.5
	100.

1669. *Muriate of Strychnia* crystallizes in acicular prisms more soluble than the sulphate.

1670. *Nitrate of Strychnia* is formed by digesting excess of strychnia in very dilute nitric acid; it yields stellated crystals, which acquire a red colour by the action of sulphuric acid. Nitric acid poured upon strychnia or its salts produces a deep red colour.

1671. The discoverers of strychnia assert that it exists in the above-mentioned seeds, combined with a peculiar acid, somewhat resembling the malic, but susceptible of crystallization; they have called it *Igasuric Acid*, and the poisonous principle existing in the seeds, appears to be an *igasurate of strychnia*.

1672. *Brucine.* This term has been applied to a peculiar alcaline substance, obtained from Angustura bark, by the above-named chemists. Its properties, as far as they have been investigated, are described in the *Annales de Chimie* (xii. p. 113.) and in the *Quarterly Journal of Science and the Arts* (ix. 189.)

1673. *Delphine* is an alcaline principle, discovered by MM. Lassaigne and Feneulle in the seeds of stavesacre (*Delphinium Staphysagria*). They obtained it by the following process: The seeds, deprived of their husks, were boiled in distilled water, the decoction filtered, boiled with a portion of pure magnesia, and re-filtered; the residue upon the filter was then boiled with highly rectified alcohol, by which the alcali was separated and obtained by evaporation in the form of a white pulverulent substance.

Delphine, when pure, appears crystalline in its moist state; its taste is bitter and acrid; when heated, it melts, and on cooling becomes brittle like resin; it is sparingly soluble in water, but readily soluble in alcohol and ether; it renders the blue of violets green, and forms very soluble salts with the acids, from which the alcalis precipitate delphine in a white gelatinous state.—*Annales de Chimie et Phys.* xii. 358.

SECTION XVI. *Bitumens, Coal, &c.*

1674. BITUMENS are fossile substances, bearing considerable resemblance to oily and resinous bodies. The chemical habitudes of several of these substances have been ably investigated by Mr. Hatchett. (*Phil. Trans.*, 1804.) The following are the principal varieties:

a. Naphtha is a pungent, odoriferous, oily liquid, either colourless or of a pale brown tint, found upon the borders of the Caspian Sea, and in certain springs in Italy. It is considerably lighter than water, volatile, and highly inflammable. When pure it appears to contain no oxygen, and hence is employed for the preservation of potassium, and the other highly oxidable metals. It consists, according to Saussure, of

Carbon	87.21
Hydrogen	12.79
	100.

b. Petroleum has most of the properties of naphtha, but is less fluid, and darker coloured. In the countries where it abounds, it is employed for burning in lamps.

c. Mineral Tar appears to be petroleum further inspissated. It is more viscid, and of a deeper colour.

d. Maltha, or *Mineral Pitch,* is a soft inflammable substance, heavier than water, and may be considered as derived from the exsiccation of mineral tar.

e. Asphaltum is found abundantly on the shores of the

Dead Sea, in Albania, and in the island of Trinidad. Its colour is brown or black; it is heavier than water, and readily soluble in naphtha.

f. Elastic Bitumen, or *Mineral Caoutchouc*, is found only in the vicinity of Castleton in Derbyshire. It is fusible and inflammable.

g. Mineral Adipocere is a fatty matter found in the argillaceous iron ore of Merthyr: it is fusible at about 160°, and inodorous when cold, but of a slightly bituminous odour when heated, or after fusion.

The above substances are insoluble in water, and difficultly soluble in alcohol, with the exception of naphtha and petroleum, which are soluble in highly-rectified alcohol.

h. Retinasphaltum is a substance which accompanies the Bovey Coal of Devonshire. It was first analyzed by Mr. Hatchett, who found it to consist of

55	Resin.
41	Asphaltum.
4	Earthy matter and loss.

i. Pit Coal. There are three chemical varieties of this important substance. The first, or *brown coal*, retains some remains of the vegetables from which it has originated. When heated it exhales a bituminous odour, and burns with a clear flame. It is generally of a tough consistency, and yields, according to Mr. Hatchett, a portion of unaltered vegetable extract, and resin.

The second variety, or *black coal*, is the ordinary fuel of this country. It exhibits no traces of vegetable origin, and consists principally of bitumen and charcoal, in variable proportions. When exposed to heat, it swells, softens, and burns with a bright flame, leaving a small quantity of ashes. Many varieties, however, abound in earthy matter, and these produce copious cinders, and burn with a less intense heat.

The products of the destructive distillation of this kind of coal have been already described (431). The residue is a hard sonorous charcoal, termed *coke*, and containing the earthy ingredients of the coal.

The third variety, or *glance coal*, consists almost entirely of charcoal, and earthy matter. It burns without flame, and when distilled produces scarcely any gaseous matter.

k. *Peat* and *Turf* consist principally of the remains of vegetables, having undergone comparatively little change. They often contain bituminous wood, and branches and trunks of trees.

l. *Mellilite*, or *Honeystone*, is a rare substance, found in the brown coal of Thuringia and in Switzerland. It is of a honey yellow colour, crystallized in octoëdra, and when analyzed by Klaproth, was found to consist of alumina, combined with a peculiar body which has been called the *mellitic acid*.—KLAPROTH'S *Essays*, ii. 89. VAUQUELIN. *Annales de Chimie*, xxxvi. 203.

SECTION XVII. *Vegetable Acids.*

1675. THE following are the principal acids, which are found ready formed in vegetable products :

1. Tartaric acid.
2. Oxalic acid.
3. Citric acid.
4. Malic acid.
5. Gallic acid.
6. Benzoic acid.

i. TARTARIC ACID.

1676. THIS acid exists in several vegetable substances ; it is one of the sour principles of many fruits, and is said to be abundant in the potato-apple. Tartaric acid is generally obtained from the *bi-tartrate of potassa.* Mix 100 parts of this salt in fine powder with 30 of powdered chalk, and gradually throw the mixture into 10 times its weight of boiling water: when the liquor has cooled, pour the whole upon a linen strainer, and wash the white powder which remains with cold water: this is a *tartrate of lime* ; diffuse it through a sufficient quantity of water, add sulphuric acid equal in weight to the chalk employed, and occasionally stir the mixture during 24 hours ; then filter, and carefully evaporate the liquor to about one-fourth its original bulk ; filter again, and evaporate with much care nearly to dryness ; redissolve the dry mass in about 6 times its weight of water, render it clear by filtration, evaporate slowly to the consistency of sirup, and set aside to crystallize. By two or three successive solutions and crystallizations, tartaric acid will be obtained in colourless crystals, soluble in 6 parts of water at 60°. According to Berzelius, the crystals contain 11.25 per cent. of water. The aqueous solution of tartaric, in common with the other vegetable acids, soon becomes mouldy, and suffers decomposition.

1677. When tartaric acid is submitted to destructive distillation, it affords a brown acid liquor, which has been termed *pyrotartarous acid.*

1678. According to Berzelius, the *tartrate of lead,* which is an insoluble salt, and easily formed by adding tartaric acid to a solution of nitrate of lead, consists of

Tartaric acid	100
Oxide of lead	167

And regarding this salt as composed of 1 proportional of acid and 1 of oxide, we obtain the number 62.5, as the representative of tartaric acid, for

$$167 : 100 :: 104.5 : 62.5.$$

1679. Tartaric acid combines with the metallic oxides, and produces a class of salts called *tartrates,* the composition of which will be obvious from the preceding datum.

1680. *Tartrate of ammonia* forms very soluble prismatic crystals, of a cooling taste. The addition of tartaric acid to its aqueous solution produces a precipitate of a difficultly soluble *bi-tartrate* of ammonia.

1681. *Tartrate of Potassa* is formed by saturating the excess of acid in *tartar*, by potassa. According to Mr. Richard Phillips (*Remarks on the Pharmacopœia,*) 100 parts of tartar require 43.5 of carbonate of potassa. The resulting salt is soluble in less than twice its weight of water ; it crystallizes in four-sided prisms, and consists of

1 proportional acid .... = 62.5
1 .... potassa ...... = 45
Tartrate of potassa ...... = 107.5

This salt is used in pharmacy as an aperient; it is the *potassæ tartras* of the *Pharmacopæia.* Its taste is saline, and somewhat bitter.

1682. *Bitartrate,* or *Supertartrate of potassa. Tartar.* This substance exists in considerable abundance in the juice of the grape, and is deposited in wine casks, in the form of a crystallized incrustation, called *argol,* or *crude tartar.* It is purified by solution and crystallization, which renders it perfectly white: when in fine powder it is termed *cream of tartar.*

It may also be formed by adding excess of tartaric acid to a solution of potassa. The mixture presently deposits crystalline grains, and furnishes a striking example of the diminution of solubility by increase of acid in the salt. Upon this circumstance the use of tartaric acid as a test for potassa depends, for soda forms an easily soluble supertartrate and consequently affords no precipitate. (578.)

Bi-tartrate of potassa is composed of

2 proportionals of acid .. = 125
1 proportional of potassa = 45
Bi-tartrate of potassa = 170

This salt requires 120 parts of water at 60°, and 30 parts at 212° for its solution.

When exposed to heat, tartar fuses, blackens, and is decomposed; and carbonate of potassa is the remaining result (569). Provided the tartar be free from lime, which however is seldom the case, this furnishes a good process for obtaining pure carbonate of potassa. The aqueous solution of tartar becomes mouldy when exposed to air, and the tartaric acid being entirely decomposed leaves a weak solution of carbonate of potassa.

The component parts of tartar render it an excellent flux in the reduction of metallic ores upon a small scale, its alcali promoting their fusion, and the carbonaceous matter tending to reduce the oxides.

1683. *Tartrate of Potassa and Ammonia* is formed by saturating the excess of acid in tartar with ammonia. It effloresces and loses ammonia by exposure to air.

1684. *Tartrate of Soda* forms acicular crystals soluble in their own weight of water. Tartaric acid, added to their solution, forms a *supertartrate of soda*, much more soluble than the corresponding salt of potassa.

1685. *Tartrate of Potassa and Soda* is prepared by saturating the excess of acid in tartar, with carbonate of soda; it is the *soda tartarizata* of the *Pharmacopœia;* it forms irregular prismatic crystals. It has long been used in pharmacy under the name of *Rochelle Salt* and *Sel de Seignette.* According to Vauquelin's analysis (FOURCROY'S *Connaissances,* vii. 240.) this salt consists of 54 tartrate of potassa + 46 tartrate of soda *per cent.*: these numbers agree with

2 proportionals of acid.. = 125
1 ———————— potassa = 45
1 ———————— soda.. = 29.5
199.5

1686. *Tartrate of Lime* is nearly insoluble in cold water, but soluble in 600 parts of boiling water; it is produced by adding chalk to tartar, as in the process for obtaining tartaric acid, where it is decomposed by sulphuric acid.

1687. *Tartrate of Potassa and Lime* may be formed by adding lime-water to solution of supertartrate of potassa, till it begins to become turbid: in a few days acicular crystals of the above triple salt are deposited, which effloresce when exposed to air.

1688. *Tartrate of Baryta* is a difficultly soluble salt.

1689. *Tartrate of Strontia* is thrown down on mixing the solutions of tartrate of potassa and nitrate of strontia. It dissolves in rather more than 300 parts of boiling water, and forms small crystals as the solution cools.

1690. *Tartrate of Magnesia* is precipitated from the sulphate by tartaric acid: it is soluble in excess of tartaric acid, and forms a crystallizable salt.

1691. *Tartrate of Manganese,* formed by dissolving protoxide of manganese in tartaric acid, is a soluble salt, and therefore not produced by adding tartaric acid or a neutral tartrate to protomuriate or protosulphate of manganese.

1692. *Tartrate of Iron.* Both the tartrates of iron are easily soluble, and no precipitate is formed by tartaric acid, or by tartrate of potassa, in solutions of iron.

1693. *Tartrate of Iron and Potassa.* This is the *Ferrum tartarisatum* of the *Pharmacopœia*, but it is most conveniently employed as a medicine in solution, which may be formed by digesting 1 part of soft iron filings with 4 of tartar; this mixture should be made into a thin paste with water, and digested for some weeks, till the acid is neutralized, fresh portions of water being occasionally added to prevent exsiccation. The solution of this compound, which contains the iron in the state of peroxide, is possessed of some curious properties, first pointed out by Mr. R. Phillips. —*Experimental Examination of the London Pharmacopœia*, 98.

1694. *Tartrate of Zinc* is formed by adding tartrate of potassa to sulphate of zinc, and appears to be a very difficultly soluble compound.

1695. *Tartrate of Tin.* Tartrate of potassa occasions a white precipitate in the protomuriate and permuriate of tin.

1696. *Tartrate of Potassa and Tin* is formed by boiling the oxide in solution of tartar; it is very soluble, and the addition of alcalis and their carbonates occasion no precipitates.—THENARD, *Annales de Chim.* xxxviii.

1697. *Tartrate of Copper* is produced by adding tartaric acid to sulphate of copper. It forms bluish-green crystals.

1698. *Tartrate of Potassa and Copper* is formed by boiling oxide of copper and tartar in water; the solution yields blue crystals on evaporation; or if boiled to dryness, furnishes one of the pigments called *Brunswick green.*

1699. *Tartrate of Lead* is thrown down in the form of an insoluble white powder on adding tartaric acid to solution of nitrate of lead. Its composition has already been adverted to (1678).

1700. *Tartrate of Potassa and Lead* is formed, according to Thenard, by boiling a mixture of tartar and oxide of lead in water.—*Annales de Chim.*, xxxviii.

1701. *Tartrate of Antimony* has not been examined.

1702. *Tartrate of Antimony and Potassa. Emetic Tartar.* This compound may be obtained by boiling protoxide of antimony, obtained by any of the processes formerly described (907) with pure supertartrate of potassa. It is the *antimonium tartarizatum* of the *London Pharmacopœia.*

Emetic tartar may be prepared by boiling a solution of 100 parts of tartar with 100 parts of finely levigated glass of antimony, or of the protoxide described above (907); the ebullition should be continued for half an hour, and the filtered liquor evaporated to about half its bulk, and set aside to crystallize: octoëdral and tetraëdral crystals of the emetic salt are thus obtained; and there is generally formed along with them a portion of tartrate of lime and potassa, which is deposited in small tufts of a radiated texture, and which may easily be separated when the mass is dried.

Mr. Phillips, in his *Experimental Examination of the London Pharmacopœia,* has stated several facts respecting the formation of this salt, which will be found useful to the manufacturer.

Emetic tartar is a white salt, slightly efflorescent, soluble in about 14 parts of cold and 2 parts of boiling water. It is decomposed by the alcalis, and when heated with ammonia, a portion of protoxide of antimony is thrown down, and a very soluble compound remains in the liquor. Sulphuretted hydrogen and hydrosulphuret of ammonia produce orange-coloured precipitates in its solution. It is decomposed by bitter and astringent vegetable infusions, but they do not render it inactive as a medicine. Mr. Phillips has shown that emetic tartar consists of 100 supertartrate of potassa + 66 protoxide of antimony. If we consider it, with Dr. Thomson, (*System*, ii. 670.) as a compound of 2 proportionals of tartaric acid, 2 of protoxide of antimony, and 1 of potassa; or as containing 1 proportional of tartrate of potassa and 1 of subtartrate of antimony, its components will stand thus:

Tartaric acid........	62.5 × 2 =	125
Protoxide of antimony,	52.5 × 2 =	105
Potassa....................	=	45
		275

1703. *Tartrate of Bismuth* has not been examined, but moist oxide of bismuth boiled with tartar forms a difficultly soluble triple salt.

1704. *Tartrate of Cobalt.* Tartrate of potassa forms no precipitate in solutions of cobalt, but their colour is much heightened by it.

1705. *Tartrate of Uranium* is a very soluble salt, not easily crystallizable.

1706. *Tartrate of Titanium* appears to be a soluble compound.

1707. *Tartrate of Cerium*, according to Hisinger and Berzelius, is formed by adding tartrate of potassa to sulphate, nitrate, or muriate of cerium. It is a soft tasteless powder, soluble in nitric, muriatic, and sulphuric acids, and in the alcalis.

1708. *Tartrate of Nickel*, formed by digesting moist oxide of nickel in tartaric acid, is a very soluble salt; tartaric acid occasions no precipitate in the soluble salts of nickel.

1709. *Tartrate of Mercury*. Tartaric acid occasions white precipitates in all the solutions of oxide of mercury not containing excess of acid.

1710. *Tartrate of Potassa and Mercury* is formed, according to Thenard, by adding solution of tartar to nitrate of mercury.

1711. *Tartrate of Silver*. Tartaric acid occasions no change in nitrate of silver, but tartrate of potassa forms a white precipitate, which is probably a tartrate of silver.

1712. *Tartrate of Silver and Potassa* is thrown down by adding tartar to nitrate of silver.

1713. *Tartrate of Alumina* is a soluble uncrystallizable compound of an astringent flavour.

ii. OXALIC ACID.

1714. This acid is found in some fruits, and in considerable quantity in the juice of the *Oxalis Acetosella*, or *wood-sorrel*, and in the varieties of *rhubarb*. It is most readily procured by the action of nitric acid upon sugar, and has hence been termed *acid of sugar*.

It may be obtained by introducing into a retort 4 ounces of nitric acid diluted with 2 of water and 1 ounce of white sugar; nitric oxide gas is copiously evolved, and when the sugar has dissolved, about one-third of the acid may be distilled over: the contents of the retort are then emptied into a shallow vessel, and in the course of two or three days an abundant crop of white crystals is deposited, and, upon further evaporation of the mother-liquor, a second portion is obtained. The whole crystalline produce is to be re-dissolved in water, and again crystallized, by which the pure acid is obtained. In this way sugar yields rather more than half its weight of oxalic acid.

1715. Oxalic acid thus procured is in the form of four-sided prisms, transparent, and of a very acid taste: they dissolve in two parts of water at 60°, and in their own weight at 212°. When carefully dried, they fall to powder, and lose more than one-third of their weight, being composed, according to Berzelius, (*Ann. de Chim.*, lxxxi.) of

Real acid........	52
Water	48
	100

1716. By repeated distillation with nitric acid, oxalic acid is resolved into carbonic acid and water; and the acid itself, and the salts containing it, as is the case with the other vegetable acids, are decomposed by heat. By distilling oxalate of lime, Dr. Thomson found the acid resolved into five new substances; namely, water, carbonic acid, carbonic oxide, carburetted hydrogen, and charcoal; and by a very elaborate analysis of these gases, he determined the composition of the acid as follows:

Oxygen	64
Carbon	32
Hydrogen	4
	100

which numbers do not quite correspond with those given by Gay-Lussac and Thenard (p. 17).

1717. The number representing the oxalic acid, founded upon Dr. Wollaston's analysis of the binoxalate of potassa, (*Phil. Trans.*, 1804.) and upon Berzelius's analysis of the oxalate of lead, (*Annales de Chimie*, No. 243.) is about 35.3. According to the latter chemist, oxalate of lead consists of 100 oxalic acid + 296.6 oxide of lead, and

296.6 : 100 :: 104.5 : 35.23.

The number deduced from the mean of the best analyses of oxalate of lime, is 35.7; and, accordingly, the mean of these, which is about 35.5, may without material error be adopted as the representative number of oxalic acid, and the composition of the oxalates will be obvious accordingly.

1718. *Oxalate of Ammonia* is a very useful test for the presence of lime. It crystallizes in long prisms, of which 45 parts require 1000 of water for their solution. Added to any soluble compound of lime, this salt produces an insoluble *oxalate of lime.*

1719. *Oxalate of Potassa* forms flat rhomboidal crystals soluble in 3 parts of water at 60°. It consists of 35.5 acid + 45 potassa. This salt, dissolved in oxalic acid, produces the *binoxalate of potassa,* which crystallizes in four-sided prisms, and consists of 2 proportionals acid 35.5 × 2 = 71 + 45 potassa. When this binoxalate is digested in dilute nitric acid, a portion of the alcali is taken up, and a salt remains, consisting of 4 proportionals of oxalic acid 35.5 × 4 = 142 + 1 proportional potassa = 45. This is the *quadroxalate of potassa,* and is the salt which exists in the wood-sorrel.

1720. *Oxalate of Soda* is sparingly soluble in water, and separates from its solution in small crystalline grains.

1721. *Oxalate of Lime.* This compound is formed by adding oxalic acid or oxalate of ammonia to any solution of lime. It is insoluble in water, and in excess of oxalic acid, but dissolves in muriatic and nitric acids: hence in testing acid solutions for lime by oxalic acid, or oxalate of ammonia, the excess of acid should be previously neutralized. This oxalate consists of 35.5 acid + 26.5 lime = 62. oxalate of lime; or of

42.74	lime
57.26	acid
100.00	

Vogel's analysis gives

43.75	lime
56.25	acid
100.	

Annals of Philosophy, Vol. v. 30.

1722. The *Oxalates of Strontia, Baryta,* and *Magnesia,* are very nearly insoluble, and with most other metallic oxalates may be formed by double decomposition. They consist respectively of one proportional of each of their components.

1723. When black oxide of manganese and superoxalate of potassa are triturated together and moistened, carbonic acid is evolved; and on adding more water, and filtering, a red solution, containing oxalic acid, potassa, and deutoxide of manganese is obtained, which after a time becomes colourless, and a triple salt is formed, containing the protoxide of manganese.

1724. *Oxalate of Iron.* The *protoxalate* crystallizes in green prisms, and may be formed either by digesting the metal, or dissolving the protoxide in the acid. The *peroxalate* is thrown down from the permuriate or persulphate of iron, in the form of a difficultly soluble yellow powder, which is taken up again by excess of oxalic acid: hence the use of this acid in removing iron-moulds, which it does without injuring the texture of linen.

1725. *Oxalate of Zinc* is formed by adding oxalic acid to a soluble salt of zinc: it is a white powder, nearly insoluble.

1726. *Oxalate of Tin* is formed, according to Bergman, by digesting the metal in the acid: the solution, slowly evaporated, gives prismatic crystals.

1727. *Oxalate of Copper.* Oxalic acid oxidizes and dissolves copper. When oxalic acid is added to persulphate or pernitrate of copper, a difficultly soluble *peroxalate of copper* is thrown down. The theoretical composition of this salt is 1 proportional peroxide of copper = 75. + 2 of oxalic acid 71. = 146.

1728. *Oxalate of Copper and Ammonia.* This, and several other triple oxalates of copper, have been described by Vogel. (SCHWEIGGER's *Journal*, vii.) By digesting peroxalate of copper in a solution of oxalate of ammonia and filtering, rhomboidal crystals were obtained on evaporation, which detonate when suddenly heated: when slowly heated they merely lose water and ammonia. From the analysis of this salt it evidently consists of 2 proportionals of oxalate of ammonia, 1 peroxalate of copper, and 6 water.

By digesting oxalate of copper in caustic ammonia, and pouring the solution thus obtained into a shallow basin, it deposits flat six-sided prisms of a blue colour, which effloresce on exposure to air. The undissolved portion of the oxalate also combines with ammonia, and produces another distinct compound. Dr. Thomson has given the following view of the composition of these salts.—*System*, ii., 624.

	1st. Subspecies.	2d. Subspecies.	3d. Subspecies.
Oxalic acid	4 prop$^{ls.}$	2	2
Ammonia	2	2	1
Peroxide of copper ..	1	1	1
Water	6	2	0

1729. *Oxalate of Copper and Potassa* is obtained by digesting percarbonate of copper in solution of binoxalate of potassa. Acicular and rhomboidal crystals are formed, which Vogel considers as two distinct salts.—THOMSON's *System*, ii., 620.

1730. *Oxalate of Copper and Soda.* Vogel has also described two subspecies of this salt.—SCHWEIGGER's *Journal*, vii.; THOMSON, ii., 621.

1731. *Oxalate of Lead* is thrown down in crystalline grains on adding oxalic acid to nitrate of lead. Its composition has already been stated (1717).

1732. *Oxalate of Antimony* has not been examined.

1733. *Oxalate of Bismuth* is deposited in crystalline grains, when solution of oxalic acid is dropped into nitrate of bismuth.

1734. *Oxalate of Cobalt* is an insoluble red powder, precipitated by oxalic acid from solutions of cobalt.

1735. *Oxalate of Uranium* is a soluble compound.

1736. *Oxalate of Nickel* is thrown down from the nitrate in the form of an insoluble green powder.

1737. *Oxalate of Mercury* is precipitated from the nitrate by oxalic acid. It is scarcely soluble, and detonates when heated.

1738. *Oxalate of Silver* is an insoluble white powder, which blackens by exposure to light. It is precipitated on adding oxalic acid to nitrate of silver, and is soluble in nitric acid.

1739. *Oxalate of Alumina* is easily formed by dissolving the newly precipitated earth in oxalic acid: it does not crystallize, but affords on evaporation a gelatinous mass, which deliquesces on exposure.

1740. The oxalic acid swallowed in large doses is an active poison, and fatal cases are not unfrequent in which this acid is taken by mistake for Epsom salt. The instant that the accident is discovered, a quantity of powdered chalk diffused in warm water should be taken, and vomiting excited as speedily as possible.

iii. CITRIC ACID.

1741. Citric acid is obtained by the following process from lemon or lime juice:

Boil the expressed juice for a few minutes, and when cold, strain it through fine linen: then add powdered chalk as long as it produces effervescence, heat the mixture, and strain as before: a quantity of citrate of lime remains upon the strainer, which, having been washed with cold water, is to be put into a mixture of sulphuric acid with 20 parts of water: the proportion of acid may be about equal to that of the chalk employed. In the course of 24 hours the citrate of lime will have suffered decomposition, and sulphate of lime is formed, which is separated by filtration. The filtered liquor, by careful evaporation, as directed for tartaric acid, furnishes crystallized citric acid.

The preparation of this acid is carried on by a few manufacturers upon an extensive scale; in different states of purity it is employed by the calico-printers, and used for domestic consumption. Many circumstances which have not here been alluded to, are requisite to ensure complete success in the operation; these have been fully described by Mr. Parkes, in the third volume of his *Chemical Essays*. The proportion of citric acid afforded by a gallon of good lemon-juice, is about 8 ounces.

1742. Citric acid forms crystals of a very sour taste, soluble in their own weight of water at 60°, and containing, according to Berzelius, 100 real acid +

26.5 water, a portion of which it loses by exposure to heat. The analysis of this, as well as of the other vegetable acids given by Berzelius, differs considerably from that of Gay-Lussac and Thenard, in consequence, as it would appear, of the latter chemists having neglected the exclusion of water of crystallization. Berzelius gives its constituents as follow:

Oxygen..........	54.831
Hydrogen	3.800
Carbon	41.369
	100.000

1743. From the analysis of citrate of lead, the representative number of citric acid appears to be 55.5; a number which closely corresponds with Berzelius's estimate of its constitution, which is

4	proportionals of oxygen....	7.5 × 4 = 30
3	———— hydrogen ..	1 × 3 = 3
4	———— carbon	5.7 × 4 = 22.8
		55.8

The number 55.5, therefore, may be adopted.

1744. *Citrate of Ammonia* crystallizes with difficulty in prisms.

1745. *Citrate of Potassa* is very soluble, deliquescent, and difficultly crystallizable. It is much used in medicine as a mild diaphoretic, and is the *Salt of Riverius* of old pharmacy.

1746. *Citrate of Soda* is difficultly crystallizable in hexaëdral tables, of a saline flavour, and soluble in somewhat less than two parts of cold water.

1747. *Citrate of Lime* has been adverted to in the preparation of citric acid. It is nearly tasteless, and scarcely soluble in water, but readily soluble in solution of citric acid: when moistened it soon grows mouldy if exposed to air. It consists of

1 proportional acid = 55.5
1 ———————— lime = 26.5
82.

100 parts, therefore, of citrate of lime may be regarded as composed of

67 citric acid
33 lime
100

1748. *Citrate of Baryta* is difficultly soluble, and forms acicular crystals, readily soluble in excess of nitric acid.

1749. *Citrate of Strontia* is crystallizable and soluble.

1750. *Citrate of Magnesia* does not crystallize.

1751. *Citrate of Manganese* is formed by digesting moist protoxide of manganese in citric acid; it produces white arborescent crystals.

1752. *Citrate of Iron.* The action of citric acid on the oxides of iron has not been examined.

1753. *Citrate of Zinc.* Zinc dissolves in citric acid with effervescence: citric acid readily dissolves the oxide of zinc, and the solution deposits small crystals, scarcely soluble in water, and of an astringent taste.

1754. *Citrate of Tin.* Neutral citrate of potassa forms no precipitate either in protomuriate or permuriate of tin.

1755. *Citrate of Copper.* Citric acid forms a pale blue precipitate in solution of sulphate and nitrate of copper.

1756. *Citrate of Lead* is thrown down in the state of a nearly insoluble powder when citric acid is added to nitrate of lead. It consists of

55.5	acid
104.5	oxide
160.	

1757. *Citrate of Antimony* is unknown.

1758. *Citrate of Bismuth* is an insoluble white compound.

1759. *Citrate of Cobalt* appears to be a soluble salt.

1760. *Citrate of Uranium,* formed by digesting oxide of uranium in citric acid, is a soluble and difficultly crystallizable salt.

1761. *Citrate of Nickel* is not thrown down by adding either citric acid or citrate of potassa to the solutions of nickel.

1762. *Citrate of Mercury.* Both the *protocitrate* and *percitrate* of mercury are insoluble, and thrown down when citric acid or a soluble citrate is added to the solutions of mercury.

1763. *Citrate of Silver* is an insoluble white powder, which blackens by exposure to light.

iv. MALIC ACID.

1764. The existence of a peculiar acid in the juice of apples, was shown by Scheele, in 1785. He obtained it by adding solution of acetate of lead to the expressed juice of unripe apples, by which a *malate of lead* was formed, and afterwards decomposed by sulphuric acid. Vauquelin obtained it by a similar process, from the juice of the *houseleek*. The same acid exists, according to Braconnot, in the berries of the *mountain-ash*, from which it was first obtained by Mr. Donovan in 1815, and called by him *sorbic acid;* the apparent differences between the malic and sorbic acids, are referable to the impurities of the former. Mr. Donovan has given the following process for its preparation. (*Phil. Trans.*, 1815.) Express the juice of the ripe berries, and add solution of acetate of lead, filter, and wash the precipitate with cold water, then pour boiling water upon the filter, and allow it to pass through the precipitate into glass jars; after some hours crystals are deposited, which are to be boiled with 2.3 times their weight of sulphuric acid, specific gravity 1.090. The clear liquor is to be poured off, and, while still hot, a stream of sulphuretted hydrogen is to be passed through it, to precipitate the remaining lead; the liquid is then filtered, and when boiled so as to expel the sulphuretted hydrogen, is a solution of the pure vegetable acid.

Malic acid may also be obtained by steeping sheet-lead in the juice of apples; in a few days, crystals of malate of lead form, which may be collected and decomposed by the very careful addition of dilute sulphuric acid.

1765. Malic acid, when carefully prepared, is a colourless liquid, very sour, and not susceptible of crystallization. It forms crystallizable salts with many of the metallic oxides, which, however, have scarcely been examined with such precision as to enable us to determine the representative number of malic acid. A detailed account of what is known respecting them will be found in M. Braconnot's Memoir, (*Annales de Chim. et Phys.*, Tom. vi.) His analysis of the crystallized *malate of lead* gives its composition thus:

Acid..........	100.
Oxide of lead..	157.4

If we deduce the number for the acid, from this datum, it will be 66, a number which closely corresponds with the other analyses of the same author.

1766. The ultimate component parts of this acid according to Vauquelin, are

Hydrogen	16.8
Carbon	28.3
Oxygen.................	54.9
	100.0

V. GALLIC ACID.

1767. This acid derives its name from the *gall-nut*, whence it was first procured by Scheele. It may be obtained by the following process:

Digest bruised galls in boiling water, with about one-sixth their weight of vellum cuttings, for some hours; then allow the mixture to cool, and filter it. Add to the filtered liquor a solution of acetate of lead, as long as it occasions any precipitate; pour the whole upon a filter, wash the precipitate with warm water, and digest it in very dilute sulphuric acid; filter, and having saturated the clear liquor with chalk, evaporate to dryness. Introduce the dry mass into a retort placed in a sand-bath, and upon the application of heat a portion of water will first rise, and afterwards a crystalline sublimate of gallic acid.

1768. There are many other processes for obtaining this acid, among which the following deserve notice: Moisten bruised gall-nuts, and expose them for four or five weeks, to a temperature of about 80°. A mouldy paste is formed, which is to be squeezed dry, and digested in boiling water; it then affords a solution of gallic acid, which may be whitened by animal charcoal, and which, on evaporation, yields gallic acid, crystallized in white needles.—Braconnot, *Annales de Chim. et Phys.*, Tom. ix. 181.

Boil an ounce of powdered galls in 16 ounces of water down to 8, and strain; dissolve 2 ounces of alum in water, precipitate the alumina by carbonate of potassa, and, after edulcorating it, stir it into the decoction; the next day filter the mixture; wash the precipitate with warm water, till this will no longer blacken sulphate of iron; mix the washing with the filtered liquor, evaporate, and the gallic acid will be obtained in acicular crystals.—Fedler, Ure's *Dictionary*.

1769. Gallic acid, when pure, is in whitish crystals, of a sour taste, and which exhale a peculiar smell when heated. It dissolves in about 10 parts of water at 60°, and in two parts at 212°. It is also soluble in alcohol and in ether. When repeatedly sublimed, this acid is altered and in part decomposed. It consists, according to Berzelius (*Annals of Philosophy*, Vol. v.) of

Hydrogen	5.00
Carbon	56.64
Oxygen	38.36
	100.00

And, according to the same authority, *gallate of lead* is composed of

Gallic acid	100
Oxide of lead	174

These proportions give the number 60 as the representative of gallic acid.

1770. The combinations of pure gallic acid with metallic bases have scarcely been examined, and consequently we have no accurate chemical history of the *gallates*. Their solutions are all very prone to decomposition, and acquire a deep brown colour. This acid forms no precipitate in solutions of potassa or of soda, but when dropped into lime-water, baryta water, or strontia water, it occasions the separation of a difficultly soluble gallate of those earths. It also causes a precipitate in solutions of zirconia, glucina, and yttria.

1771. When an infusion of galls is added to certain metallic solutions, it forms precipitates composed of tannin, gallic acid, and the metallic oxide, and as these are often of different colours, the infusion is employed as a test for such metals. The following metals in solution are thus thrown down, of the annexed colours:

METAL.	SOLUTION.	PRECIPITATE.
MANGANESE	Neutral protomuriate	Dirty yellow
IRON . .	Neutral protosulphate	Purple
Ditto . . .	Permuriate	Black
ZINC . .	Muriate	Dirty yellow
TIN . . .	Acid protomuriate	Straw-colour
Ditto . . .	Acid permuriate	Fawn-colour
CADMIUM .	Muriate	?
COPPER . .	Protomuriate	Yellow brown
Ditto . . .	Pernitrate	Grass green
LEAD . .	Nitrate	Dingy yellow
ANTIMONY .	Tartrate of antimony and potassa	Straw colour
BISMUTH .	Tartrate of bismuth and potassa	Yellow and copious
COBALT . .	Muriate	0
URANIUM .	Sulphate	Bluish black
TITANIUM .	Acid muriate	Brown
Ditto . . .	Neutral sulphate	Blood red
CERIUM . .		Yellowish
TELLURIUM .		Yellow
ARSENIC .	White oxide	Little change
Ditto . . .	Arsenic acid	0
MOLYBDENUM		Brown
NICKEL : .	Sulphate	Green
MERCURY .	Acid protonitrate	Yellow
Ditto . . .	Acid pernitrate	Yellow
Ditto . . .	Corrosive sublimate	0
OSMIUM . .	Aqueous solution of oxide	Purple becoming blue
RHODIUM . .		
PALLADIUM .		
SILVER . .	Nitrate	Curdy and brown after some time
GOLD . .	Muriate	Deep brown
PLATINUM .	Muriate	Brownish green

The omitted metals are either not precipitated, or their action has not been examined.

1772. Of these compounds, the *tannogallate of iron* is of the most importance, as forming the basis of writing ink, and of black dyes.

When an infusion of galls is dropped into a solution of sulphate of iron, it produces a deep purple precipitate, which is a very long time in subsiding; it becomes black by exposure to air. In writing ink, this precipitate is retained in suspension by mucilage, and the following proportions appear the best which can be used:

Finely bruised galls, 3 ounces
Green vitriol (protosulphate of iron)
Logwood shavings
Gum arabic, of each 1 ounce
Vinegar, 1 quart.

Put these ingredients into a bottle, and agitate them occasionally during twelve or fourteen days; then allow the coarser parts to settle, and pour off the ink for use.

The tendency of ink to become mouldy is much diminished by keeping a few cloves in the ink-bottle, or by dissolving in each pint of the ink about three grains of corrosive sublimate.

The colour of common writing-ink is apt to fade, in consequence of the decomposition of its vegetable matter; and when thus illegible, it may often be restored by washing the writing with vinegar, and subsequently with infusion of galls. Acids also destroy its colouring matter, and those inks which resist their action, contain some other colouring principle, usually finely powdered charcoal. Common writing ink is, for this reason, much improved by dissolving in the quantity abovementioned about an ounce of *Indian ink*, which is lamp-black, made into a cake with isinglass.

In dyeing black, the stuff is first impregnated with a solution of the gall-nut, and afterwards the colour is brought out by the application of sulphate, or acetate of iron (1596.)

Upon these subjects much valuable information will be found in LEWIS'S *Philosophical Commerce of the Arts*, and in AIKIN'S *Dictionary*.

1773. In the *Philos. Trans.* for 1817, I have described the properties of a species of galls from China, which furnish very pure gallic acid, and which, could they be abundantly obtained, would certainly prove a valuable substitute for common galls, in many of the processes in which they are employed.

vi. BENZOIC ACID.

1774. Benzoic acid may be obtained by sublimation, from *benzoin*, which is a resinous exudation from the *Styrax benzoe* of Sumatra; it also exists in the *Balsam of Peru* and of *Tolu*. If these substances be heated in a crucible, with a cone of paper attached to its mouth, the acid condenses in it in fine acicular crystals, which were formerly called *flowers of benzoin*. A good process for procuring this acid is that recommended by Mr. Hatchett, which consists in digesting benzoin in sulphuric acid, when it affords a copious sublimate of pure benzoic acid. (*Additional Experiments on Tannin, Phil. Trans.*, 1808.) It may also be obtained by boiling a pound and a half of powdered benzoin with 4 ounces of quicklime, in 6 or 8 quarts of water. When cold the clear liquor is decanted, and the residuum again boiled in half the former quantity of water. The liquors thus obtained are boiled down to half their bulk, filtered, and mixed with muriatic acid, as long as it occasions a precipitate, from which the liquor is poured off, and when dry it is put into an earthen vessel, placed in a sand heat, and sublimed into paper cones.

In the tenth volume of Nicholson's *Journal* I have detailed several experiments on benzoin, and have shown the relative quantity of acid afforded by the several processes which have been recommended for obtaining it.

1775. Benzoic acid, when it has been thus sublimed, is in the form of soft feathery crystals, of an acrid and slightly sour taste, soluble in about 30 parts of boiling water, and very sparingly soluble in cold water. It is much more soluble in alcohol, and this solution easily furnishes it in prismatic crystals.

1776. Berzelius' analysis gives the following as the components of this acid, and of the benzoate of lead:

Hydrogen	5.16
Carbon	74.41
Oxygen	20.43
	100.00

Benzoic acid	100	=194
Oxide of lead	94	

Whence it appears that the representative number of benzoic acid is 112.

1777. *Benzoate of Ammonia* forms deliquescent plumose crystals, very soluble in water. Berzelius recommends this salt as a precipitant of iron, which it throws down of an orange colour.

1778. *Benzoate of Potassa* is a very soluble deliquescent salt; if it be digested with benzoic acid, a *bibenzoate of potassa* results, which, according to Bucholz (*Annales de Chimie,* lxxxiv.) forms acicular and lamellar crystals, requiring ten parts of water for their solution.

1779. *Benzoate of Soda* forms efflorescent crystals, very soluble in water.

1780. *Benzoate of Lime* forms acicular crystals, sparingly soluble in cold water. Vauquelin found this salt in the urine of the cow. Benzoate of ammonia forms a copious white precipitate when added to muriate of lime, which is soluble in hot water.

1781. *Benzoate of Baryta* is soluble and crystallizable.

1782. *Benzoate of Strontia* is also a soluble salt.

1783. *Benzoate of Magnesia* forms soluble plumose crystals.

1784. *Benzoate of Manganese* forms beautiful prismatic crystals.

1785. *Benzoate of Iron.* Benzoate of ammonia forms an insoluble *perbenzoate* when added to solutions of peroxide of iron, of a yellow colour: in the protosalts of iron it also forms a white precipitate.

1786. *Benzoate of Zinc* forms soluble acicular crystals when there is excess of acid: the neutral benzoate is insoluble.

1787. *Benzoate of Tin* is insoluble.

1788. *Benzoate of Copper* is a fine blue insoluble compound.

1789. *Benzoate of Lead* is insoluble, except there be excess of acid; it then forms nacreous crystals.

1790. *Benzoate of Bismuth* forms white acicular crystals, permanent in the air, soluble in water, and sparingly soluble in alcohol. (TROMMSDORF, *Ann. de Chim.*, xi.) When benzoate of ammonia is added to acid nitrate of bismuth, it forms an insoluble white precipitate; Trommsdorf's salt therefore is probably a *bibenzoate.*

1791. *Benzoate of Cobalt.* Benzoate of ammonia forms no precipitate in solutions of cobalt.

1792. *Benzoate of Uranium* is a difficultly soluble straw-coloured compound, when formed by adding benzoate of ammonia to nitrate of uranium.

1793. *Benzoate of Nickel.* Solutions of nickel are only rendered slightly turbid by benzoate of ammonia, benzoate of nickel is probably therefore a soluble salt.

1794. *Benzoate of Mercury.* Benzoic acid forms white precipitates in the solutions of mercury.

1795. *Benzoate of Silver,* obtained by digesting moist oxide of silver in benzoic acid, forms acicular crystals; but benzoate of ammonia forms an abundant insoluble precipitate in solution of nitrate of silver.

1796. *Benzoate of Alumina* forms arborescent crystals.

Besides the vegetable acids which have now been described, there are a few others of considerably inferior interest and importance; namely, the

1797. *Moroxylic acid*, discovered by Klaproth, in the bark of the *morus alba*, or *white mulberry* (Nicholson's *Journal*, vii.) An exudation was observed upon this bark, which proved to be a compound of a peculiar acid and lime, or a *moroxylate of lime*; its solution was decomposed by acetate of lead, and the *moroxylate of lead* thus obtained decomposed by dilute sulphuric acid, furnished a solution of moroxylic acid, which gave acicular crystals on evaporation. This acid has the taste of succinic acid; it is soluble in water and alcohol, and does not, like some of its salts, form precipitates in metallic solutions. The quantity of this acid, examined by Klaproth, was so small as to leave some doubt respecting its distinct nature.

1798. *Boletic acid* was obtained by Braconnot from the *boletus pseudo-ignarius* (*Ann. de Chim.* Tom. lxxx.) by cautiously evaporating its expressed juice to the thickness of sirup, digesting it in alcohol, dissolving the residue in water, and adding nitrate of lead to the aqueous solution; the precipitate washed and diffused through water, was decomposed by sulphuretted hydrogen; the liquor was then filtered and evaporated till it formed crystals, which were purified by solution in alcohol and evaporation. These crystals are boletic acid; they are prismatic, and require 180 parts of water at 68°, and 45 of alcohol for their solution, which reddens blues and precipitates nitrate of lead, and the salts containing the peroxide, but not those of the protoxide of iron. This acid sublimes with little alteration, when heated. Braconnot has examined the *boletates of ammonia, potassa, lime*, and *baryta*, but his researches have not as yet been confirmed by any other chemist.—Thomson's *Syst. 6th edit.* ii. 157.

1799. *Fungic acid* was procured by the same chemist from the *boletus juglandis*, and some other fungi; it is deliquescent and uncrystallizable.—*Annales de Chimie*, lxxxvii.

1800. *Kinic acid* was discovered by Vauquelin, in *Cinchona.* When a strong cold infusion of this bark is set aside, crystals of *kinate of lime* are sparingly deposited by it, which may be decomposed by oxalic acid. The kinic acid is crystallizable, sour, and bitter: the *kinates* are for the most part soluble salts; it is chiefly distinguished by forming no precipitate in solutions of lead and silver. —*Annales de Chimie*, lix.

1801. In the astringent root of the *Krameria triandra*, M. Peschier has announced the existence of what he considers as a distinct substance, which he calls *krameric acid.*—*Journal de Pharmacie*, vi.

1802. M. Braconnot has given the term *Ellagic acid* (from the word *galle* reversed) to an acid body which he has detected, along with gallic acid, in infusion of galls, but its characters have been but imperfectly ascertained.

1803. *Zumic acid* was discovered by the same chemist in vegetable substances, which have undergone acetous fermentation—THOMSON'S *Syst.* Vol. ii. p. 189.

SECTION XVIII. *Of the Parts of Plants.*

1804. IN the preceding Sections the principal proximate components of vegetables have been described, and the composition of some of their detached parts has been adverted to; such of these as have not been previously noticed and as have been examined with any degree of precision, remain to be described in this Section, under the heads of

Roots.
Barks.
Woods.
Leaves.
Flowers.
Seeds.
Fruits.
Bulbs.
Lichens.
Fungi.

i. ROOTS.

1805. *a. Ipecacuanha.* This root is the produce of the *Callicocca Ipecacuanha* (LINNÆAN *Trans.* vi.) It has been examined by MM. Pelletier and Majendie, and an account of their researches is published by M. Robiquet, in the *Annales de Chimie et Phys.* iv. 172. 100 parts of this root, deprived of the woody fibre which traverses its centre afforded

Fatty matter	2
Emetine	14
Gum	16
Starch	18
Woody fibre	48
A trace of wax	
Loss	2
	100

The means of separating the emetic principle have already been described (1580).

1806. *b. Valerian*, the root of the *Valeriana officinalis*, has been examined by Trommsdorf (*Annales de Chimie*, lxx.) The recent root loses about three-fourths its weight in drying. It affords, when distilled with water, an aromatic volatile oil; it also contains starch, gum, resin, and extractive.

1807. *c. Turmeric* is the root of the *Curcuma longa*, a plant cultivated in the East Indies, and used as a condiment, especially in *Curry powder*. Digested in water or alcohol, it furnishes a large proportion of yellow colouring matter, which would be very useful to the dyer, could it be rendered permanent. Most of the acids render it paler, and the alcalis change it to a deep brick-red; hence its use as a test of the presence of alcaline matter. It is also reddened by boracic acid, and by muriatic acid gas.

1808. *d. Madder* is the root of the *Rubia Tinctorum*, and is an article of great importance in dyeing; it grows wild in most parts of the south of Europe, and is largely cultivated in some parts of Holland and the Levant; its red colour is apt to be injured by drying, a process requiring much caution. Good madder has a strong and peculiar smell; it exhibits, when cut, a cortical and a woody part of a red colour, intermixed in the former with yellow spots. The red portion is most soluble.—AIKIN'S *Dictionary*. Art. DYEING. BERTHOLLET, *Elem. de Teinture*, ii.

1809. *e. Rhubarb* is the root of the *Rheum palmatum*, largely cultivated in the northern parts of China; its colour is brown, with streaks of red and white. The following are the component parts, separable from the finest kinds of Turkey rhubarb.—**Brande**, *Quarterly Journal of Science and the Arts*, x. 291.

Water	8.2
Gum	31.0
Resin	10.0
Extract, tan, and gallic acid	26.0
Phosphate of lime	2.0
Malate of lime	6.5
Woody fibre	16.3
	100.0

1810. *Liquorice*, the root of the *Glycyrrhiza glabra*, has been examined by M. Robiquet, who found in it the following substances.—*Annales de Chimie*, lxx.

i. Starch.
ii. Gluten.
iii. Liquorice sugar;
vi. Phosphate and malate of lime and magnesia,
v. An acrid oil,
vi. A crystallizable substance resembling asparagin.
vii. Woody fibre.

The sugar is soluble in water and in alcohol, but not convertible into alcohol by fermentation; nor into oxalic acid by the action of nitric acid.

1811. *Jalap*, the root of the *Convolvulus Jalappa*, is employed in medicine as a cathartic. It is imported from South America. It has not been submitted to any accurate chemical analysis, but its activity is generally regarded as chiefly resident in its resin. The finest and densest jalap affords about 12 *per cent.* of resin, when digested in alcohol; water takes up about 30 or 35 *per cent.* of the remainder, and the residue appears to be inert woody fibre.

1812. *Gentian* is the root of the *Gentiana lutea*; according to Mr. Henry (*Annals of Philosophy*, xvi. 89,) it contains the following substances:

i. A substance resembling bird-lime.
ii. A resin combined with an oil, which gives to gentian its peculiar odour.
iii. A bitter extractive principle.
iv. Gum and colouring matter.
v. Phosphate of lime?

ii. BARKS.

1813. *a. Cinchona.* The varieties of Peruvian bark have been examined by MM. Pelletier and Caventou. In the *cinchona lancifolia*, or *pale bark*, they found the following constituent parts:

i. Cinchonine, combined with kinic acid.
ii. Green fatty matter.
iii. Red and yellow colouring matter.
iv. Tannin.
v. Kinate of lime.
vi. Gum.
vii. Starch.
viii. Lignin.

1814. *Cinchonine*, according to the above chemists, is a salifiable base, forming white acicular crystals, and requiring 7000 parts of water for solution; dissolved in alcohol it has a bitter taste. It is difficultly soluble in the fixed and volatile oils and in ether.

1815. *Sulphate of Cinchonine* is easily crystallizable, and moderately soluble; it consists of

Cinchonine	100
Sulphuric acid	13

1816. *Muriate of Cinchonine* is much more soluble than the sulphate, and contains

Cinchonine	100
Muriatic acid	7.9

1817. *Nitrate of Cinchonine* appears to be uncrystallizable. Gallic, oxalic, and tartaric acids form difficultly soluble salts with cinchonine; the precipitate occasioned by dropping tincture of galls into infusion of pale bark is a *gallate of cinchonine.*

1818. In the *yellow bark* (*cinchona cordifolia*) MM. Pelletier and Caventou discovered a salifiable base, which they term *Quinine*, the sulphate of which is composed of

Quinine	100
Sulphuric acid	10.9

1819. *Acetate of Quinine* forms bundles of flat acicular crystals, while the corresponding salt of cinchonine crystallizes in small tables. The *gallate, oxalate,* and *tartrate of quinine,* are nearly insoluble, but quinine is very soluble in sulphuric ether.

1820. In the *red bark* (*cinchona oblongifolia*) the two salifiable bases above described are found united.—*Quarterly Journal of Science and the Arts,* x. 388.

1821. *b*. *Cascarilla*, the bark of the *Croton Eleutheria* contains, according to Trommsdorff—*Annales de Chimie*, xxii.

	Parts.
Mucilage and bitter principle	864
Resin	688
Volatile oil	72
Water	48
Woody fibre	3024
	4696

1822. *c*. The bark of the *horse chestnut* (*Æsculus hippocastanum*,) has been partially examined by M. Henry (*Annales de Chimie*, lxxvii.) It appears to contain scarcely any resin; water and diluted alcohol dissolve nearly the whole of its soluble contents, which are chiefly extractive and mucilage. Tincture of galls does not render its infusion turbid, it does not therefore probably contain the peculiar substances discovered in Peruvian bark.

iii. Woods.

1823. *a*. *Brazil Wood* is the produce of the *Cæsulpina crista*, growing in Brazil, in the Isle of France, Japan, and other countries: the wood is hard and heavy, and though pale when recent, it acquires a deep red colour by exposure. Digested in water it affords a fine red infusion, of a sweetish flavour; the residue, which appears nearly black, imparts much of its colour to alcaline liquors. With alcohol it gives a deep red tincture: alcalis and soap convert its red colour to a fine purple, hence paper tinged with Brazil wood is sometimes used as a test for alcalis; acids render it yellow; alum produces a fine crimson lake with infusion of Brazil wood; muriate of tin forms with it a crimson precipitate, bordering on purple; the salts of iron give a dingy purple colour. Sulphuretted hydrogen destroys the colour of infusion of brazil wood, but it reappears on expelling the gas.—Chevreul, *Annales de Chimie*, lxvi.

1824. *b. Red Sandal*, or *Saunders*, is the wood of the *Pterocarpus santalinus*, a native of several parts of India. Its deep red colouring matter is insoluble in water, but readily soluble in alcohol; it is chiefly employed for colouring a few pharmaceutical tinctures. The insolubility of its colouring principle in water furnishes a ready mode of distinguishing between it and brazil wood; and its solubility in alcohol renders it probable that it is of a resinous nature.

1825. *c. Logwood*, the produce of the *Hæmatoxylon campechianum*, has already been noticed as containing a peculiar colouring principle (1571). It imparts a fine purple or crimson colour to pure water, but its tint is altered by the slightest metallic impregnation; alcalis deepen it, and acids render it paler; alum forms with it a violet-coloured lake; sulphate of iron renders the infusion of logwood deep purple, or nearly black; sulphate of copper and acetate of lead throw down brown and purple precipitates; and muriate of tin precipitates the whole of the colouring matter, in the form of a purple compound. The colours which logwood produces are for the most part very perishable.—Bancroft, *on Permanent Colours*, ii. 338. Chevreul, *Annales de Chimie*, lxvi. 254.

iv. LEAVES.

1826. *a. Senna.* According to Lagrange (*Annales de Chimie*, xxvi.) the leaves of the *Cassia senna* are characterized by containing a peculiar extractive principle, which, by long boiling, passes into a resinous substance, in consequence of absorbing oxygen: they also contain a resin which resists the action of water, and is soluble in alcohol; the whole of the soluble matter amounts to about one-third the weight of the senna. In the *London Medical Repository*, Vol. xv., 169, the effects of the various re-agents on infusion of senna are detailed by Mr. Batley.

1827. *b. Nightshade.* The leaves of the *Atropa Belladonna* contain, according to Vauquelin (*Annales de Chimie*, lxxii.),

i. Vegetable albumen.
ii. A bitter narcotic principle.
iii. Nitrate, muriate, sulphate, binoxalate, and acetate of potassa.

Dr. Brandes has announced the existence of a new vegetable alcali in this plant, which he calls *atropia.* It forms brilliant acicular crystals, tasteless, and difficultly soluble in water and alcohol. It affords distinct salts with the acids; the *Sulphate of Atropia* consists of

Sulphuric acid	36.52
Atropia	38.93
Water	24.55
	100.00

1828. *c. Hyoscyamus Niger*, or *Henbane.* In the leaves of this plant Dr. Brandes has also ascertained the presence of a peculiar, and highly poisonous salifiable base which he calls *hyoscyama*. With the acids it forms characteristic salts; it crystallizes in long prisms.

V. FLOWERS.

1829. The colouring matter of most flowers is extremely fugitive, and is generally much changed by mere exsiccation. They usually communicate their colour to water; the infusion of blue flowers is generally reddened by acids, and changed to green or yellow by alcalis; that of yellow flowers is made paler by acids, and alcalis render it brown; the red infusion of many flowers is exalted in tint by acids, and changed to purple, and in some instances, to green by alcalis.

It is probable that one and the same principle gives colour to several of the blue and red flowers, but that the presence of acid in the latter produces the red; the petals of the red rose, triturated with a little carbonate of lime and water, give a blue liquor; alcalis render it green, and acids restore the red.

1830. A colouring matter, analogous to that of the violet, exists in the petals of red clover, in the red tips of those of the common daisy, of the blue hyacinth, the hollyhock, lavender, in the inner leaves of the artichoke, and in numerous other flowers; reddened by an acid, it colours the skin of several plums, and the petals of the scarlet geranium and pomegranate. Some flowers which are red, become blue by merely bruising them; this is also the case with the colouring matter of red cabbage leaves, and of the rind of the long radish. Mr. Smithson has suggested that the reddening acid is in these cases the carbonic, which escapes on the rupture of the vessels which enclose it.

1831. The petals of the common *corn-poppy*, rubbed upon paper, give a purple stain, little altered by ammonia, or carbonate of soda, but made green by caustic potassa. The infusion of poppy-petals in very dilute muriatic acid, is florid red; chalk added, renders it of the colour of port wine; carbonate of soda in excess gives the same colour, but excess of potassa changes it to green and yellow. The expressed juice of the black mulberry possesses nearly the same properties.—SMITHSON, *Phil. Trans.* 1818, 110.

1832. The flowers of the *carthamus tinctorius*, or *safflower*, cultivated chiefly in Spain and the Levant, contain a yellow colouring matter, easily soluble in water, and a red, soluble in alcohol and weak alcaline liquors; the latter only is employed. *Rouge* is the red colouring matter of the carthamus, obtained by digesting the washed flowers in solution of carbonate of soda, and adding lemon juice, which throws it down in the form of a fine powder, which is dried and mixed with a portion of powdered talc; carthamus is also used for dyeing silk. The details of the analysis of carthamus will be found in the *Essays* of Dufour and Marchais.—*Annales de Chimie*, xlviii.

vi. SEEDS.

1833. Starch is an essential component of the greater number of seeds, and it is generally united in them with a variable portion of gluten, and often of fixed and of volatile oil. The component parts of wheat-flour, and of several esculent grains, have already been stated (1566,) and a variety of curious details respecting them will be found in EINHOFF'S *Papers*, in GEHLEN'S *Journal*.

Sir H. Davy has also examined a number of seeds, with a view to determine their relative nutritive powers; the results of his experiments are seen in the table at the end of this section.

1834. *Almonds*, the seed of the *amygdalus communis*, consist of an albuminous substance and oil; the latter may be obtained by expression, five pounds yielding about one pound of cold drawn oil, and about a pound and a half when aided by heat. The bitter almond affords by pressure an oil analogous to that from the former; but if the expressed cake be distilled with water, a portion of volatile oil, eminently poisonous, and smelling strongly of the almond, is obtained; this oil is used as a flavouring material by confectioners, and by the manufacturers of noyau. In the *Philosophical Transactions* for 1811, Mr. Brodie has detailed a variety of experiments illustrative of its action as a poison, in which, as well as from its odour, it appears identical nearly with hydrocyanic acid.

1835. *Lentiles*, the seed of the *ervum lens*, contain, according to Einhoff, in 3840 parts,

Woody fibre	720
Albumen	44
Earthy phosphates	22
Extractive, soluble in alcohol	120
Gum	230
Starch	1260
Gluten	1433
Loss	11
	3840

1836. The seeds of the *white lupine* (*lupinus albus*) contain, according to Fourcroy and Vauquelin (*Ann. du Muséum*, No. xxxvi), gluten, and a green acrid oil, with a considerable portion of phosphate of lime and magnesia, but no starch or sugar.

1837. *Coffee*, the seed of the *Coffea Arabica*, has been examined both in its raw and roasted state. From 64 parts of raw coffee, Cadet (*Ann. de Chimie*, lviij.) obtained

Gum	8.
Resin and bitter extract	2.0
Gallic acid	3.5
Insoluble matter	43.5
Loss, including a trace of albumen	7.0
	64.

Hermann has given the following comparative analysis of coffee from the Levant and from Martinique (CRELL's *Annals*, ii.), the results of which differ much from those of Cadet:

	Levant.	Martinique.
Resin	74	68
Extractive	320	310
Gum	130	144
Fibrous matter	1335	1386
Loss	61	12
	1920	1920

When coffee is roasted it undergoes a peculiar change of composition, attended by the formation of tan, and a volatile, fragrant, and aromatic principle ; but in this state it has not been examined with any precision.

1838. *Pepper.* The seed of the *piper nigrum* has not been satisfactorily analyzed: it imparts its acrimony to alcohol and to water; it contains a species of volatile oil, with starch and extractive matter.—NICHOLSON's *Journal*, ii.

1839. *Mustard.* The seed of the *sinapis nigra* derives its acrimony from a volatile oil; it also contains a tasteless fixed oil, albumen, gum, and traces of sulphur and earthy salts.

1840. The seeds of the *lycopodium clavatum*, or *common club moss*, have been analyzed by Bucholz. (GEHLEN's *Journal*, vi.) From 1000 parts he obtained

Fixed oil	60
Sugar	30
Mucilage	15
Insoluble residue	895
	1000

This seed has the appearance of a fine yellow powder, which deflagrates when projected into the flame of a candle; it is used in theatres to imitate lightning; and the German apothecaries employ it to prevent the adhesion of pills.

1841. *Annotta* is the produce of the *bixa orellana*, a tree cultivated in various parts of America. When the capsules are ripe, the seeds are bruised and steeped for several weeks in water, until converted into a pulp, which is allowed to putrefy, and being diffused through a fresh portion of water, is heated till a scum rises, which is successively removed as it forms, and being carefully dried, is made up into cakes, and wrapped in palm leaves for exportation.

Annotta is soluble in water and alcohol; the solutions have a disagreeable smell, and are of an orange colour; alcalis render it more soluble, and increase its colour: alum and the acids separate it from its solutions in the form of a yellow sediment: it is used for dyeing silk and colouring cheese.

vii. FRUITS.

1842. The acid matter contained in fruits is either the tartaric, oxalic, citric, or malic; or a mixture of two or more of them; but the nature and proportion of the acid varies at different periods of their growth; gluten and starch are found in some fruits, and a gelatinizing substance, which has sometimes been regarded as identical with animal jelly, but which is probably a compound of gum and one or more vegetable acids.

1843. Most of our common fruits also contain sugar, and it exists in all those the juice of which is susceptible of vinous fermentation. In some fruits the quantity of sugar is increased by mashing and exposure to air; this is remarkably the case with some of the rough-flavoured apples used for cider, the pulp of which becomes brown, and at the same time sweet by a few hours' exposure.

1844. The colouring matter of fruits seems in most cases to bear a strong resemblance to that of flowers. The red juice of the mulberry was found to exhibit the same characters as the colouring principle of the wild poppy; carbonated alcalis render it blue, but caustic potassa changes it to green and yellow: the juice of red currants, cherries, elder berries, and privet berries, and the skin of the buckthorn berry, appear to contain a similar colouring principle.

1845. The unripe berries of the buckthorn furnish a juice, which, when inspissated, is known under the name of *sap green.* It is soluble in water, and rendered yellow by carbonate of soda and caustic potassa; the acids redden it, and carbonate of lime restores it to green, which is therefore probably the proper colour of the substance. (Smithson, *Phil. Trans.*, 1818, p. 116).

1846. The fruit of the *wild cucumber* (*cucumis elaterium*) furnishes a very acrid juice, which deposits the powerful cathartic known under the name of *elaterium.* This substance occurs in commerce in thin cakes of a greenish colour and bitter taste; it derives its cathartic power from a small portion of a very active principle, which Dr. Paris has called *Elatin: (Pharmacologia,* 223, 3d. Edit.) from 10 grains of elaterium he obtained

Water	0.4
Extractive	2.6
Fecula	2.8
Gluten	0.5
Woody matter	2.5
Elatin	1.2
Bitter principle	
	10.

viii. Bulbs.

1847. The *potato,* which is the bulbous root of the *solanum tuberosum,* has been examined by Dr. Pearson and by M. Einhoff; from 100 parts, the latter chemist obtained

Starchy matter	22
Albumen and mucilage	5.4
	27.4

The average quantity of nutritive matter contained in the potato, amounts to about one-fourth its weight. When potatoes become sweet by exposure to frost, a portion of the mucilage passes into the state of sugar, for Einhoff found the quantity of starch undiminished.

1848. *Garlic,* or the bulbous root of the *allium sativum,* has been examined by Cadet. (*Ann. de Chim.,* lix.) It loses by drying about two-thirds of its weight; its juice is viscid, and very slightly sour; it yields coagulated albumen when heated, and when distilled with water furnishes an acrid oil having a strong odour of garlic.

1849. The bulb of the *Allium Cepa,* or *Onion,* has been analyzed by Fourcroy and Vauquelin (*Ann. de Chimie,* lxv.). The juice of this root, when exposed to a temperature of about 70°, forms a quantity of vinegar, and deposits a sediment having the characters of gluten combined with oil and sulphur. In the acetous solution is contained a substance having the properties of manna, and which is probably a product of the fermentation, for none could be detected in the recent juice.

1850. *Squill*, the bulbous root of the *Scilla maritima*, contains, according to Vogel, (*Annales de Chim.* lxxxiv.) a peculiar bitter principle, which he terms *Scillitin*, combined with gum, and a considerable portion of tannin.

ix. LICHENS.

1851. There are several lichens which abound in colouring matter; of these the most remarkable is the *Lichen rocella*, which grows in the South of France and in the Canary Islands, and which affords the beautiful but perishable blue called *litmus*, *archil*, or *turnsole*. The moss is dried, powdered, mixed with pearlash and urine, and allowed to ferment, during which it becomes red, and then blue; in this state it is mixed with carbonate of potassa and chalk, and dried. It is used for dyeing silk and ribands, and by the chemist is a most delicate test of acids, which it indicates by passing from blue to red; the blue colour is restored by alcalis, which do not render it green. *Cudbear* appears to be a similar preparation of the *lichen tartareus.*—BANCROFT *on Colours*, i., 300.

Mr. Smithson has thrown some doubt upon the use of alcalis in the precipitation of litmus, for he found its tincture produce no change on solutions of muriate of lime, nitrate of lead, muriate of platinum and oxalate of potassa; he at the same time suggests the idea of its being a compound of a vegetable principle with potassa.—*Phil. Trans.*, 1818, p. 112.

1852. The *Lichen Islandicus*, or *Iceland Moss*, has been subjected to analysis by Berzelius. (*Annales* *de Chimie*, xc.) He obtained from it the following substances:

Syrup	3.6
Bi-tartrate of potassa Tartrate of lime Phosphate of lime	1.9
Bitter principle	3.0
Wax	1.6
Gum	3.7
Colouring extract	7.0
Starch	44.6
Insoluble starchy matter	36.6
	102.0

x. FUNGI OR MUSHROOMS.

1853. M. Braconnot, who has lately examined many fungi with minute attention, has given the name *fungin* to the insoluble spongy portion which they contain, and which in many respects resembles lignin; he has also detected in them two peculiar acids, which he terms *fungic acid* (1799) and *boletic acid* (1798); the method of extracting which has been above described. A peculiar fatty matter, or adipocere, has been found by Vauquelin and Braconnot, in several of the fungi; an albuminous substance, and salts, some of which are boletates and fungates, have also been detected in them, but the analyses are too abstruse, and the results too complicated, to be regarded as perfectly satisfactory.—*Annales de Chimie*, lxxix., lxxxv., *&c.*

1854. The following table, drawn up by Sir H. Davy, exhibits the relative proportions of soluble and of nutritive matter contained in 1000 parts of the different vegetable substances enumerated in the first column (*Agricultural Chemistry*, 4to., p. 131.):

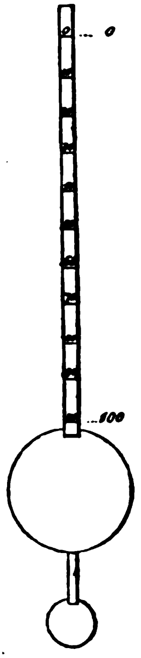
VEGETABLES or VEGETABLE SUBSTANCE.	Whole quantity of Soluble or Nutritive Matter.	Mucilage or Starch.	Saccharine Matter or Sugar.	Gluten or Albumen.	Extract, or matter rendered insoluble during evaporation.
Middlesex Wheat, average crop .	955	765	—	190	—
Spring Wheat	940	700	—	240	—
Mildewed Wheat of 1806 . . .	210	178	—	32	—
Blighted Wheat of 1804	650	520	—	130	—
Thick-skinned Sicilian Wheat of 1810	955	725	—	230	—
Thin-skinned Sicilian Wheat of 1810	961	722	—	239	—
Wheat from Poland	950	750	—	200	—
North American Wheat	955	730	—	225	—
Norfolk Barley	920	790	70	60	—
Oats from Scotland	743	641	15	87	—
Rye from Yorkshire	792	645	38	109	—
Common Bean	570	426	—	103	41
Dry Peas	574	501	22	35	16
Potatoes	from 260 to 200	from 200 to 155	from 20 to 15	from 40 to 30	—
Linseed Cake	151	123	11	17	—
Red Beet	148	14	121	14	—
White Beet	136	13	119	4	—
Parsnip	99	9	90	—	—
Carrots	98	3	95	—	—
Common Turnips	42	7	34	1	—
Swedish Turnips	64	9	51	2	2
Cabbage	73	41	24	8	—
Broad-leaved Clover	39	31	3	2	3
Long-rooted Clover	39	30	4	3	2
White Clover	32	20	1	3	5
Sainfoin	39	28	2	3	6
Lucerne	23	18	1	—	4
Meadow Fox-tail Grass	33	24	3	—	6
Perennial Rye Grass	39	26	4	—	5
Fertile Meadow Grass	78	65	6	—	7
Roughish Meadow Grass . . .	39	29	5	—	6
Crested Dog's-tail Grass	35	28	3	—	4
Spiked Fescue Grass	19	15	2	—	2
Sweet-scented Soft Grass . . .	82	72	4	—	6
Sweet-scented Vernal Grass . .	50	43	4	—	3
Fiorin	54	46	5	1	2
Fiorin cut in Winter	76	64	8	1	3

SECTION XIX. *Phenomena and Products of Fermentation.*

1855. THE term *fermentation* is employed to signify the spontaneous changes which certain vegetable solutions undergo, placed under certain circumstances, and which terminate either in the production of an intoxicating liquor, or of vinegar; the former termination constituting *vinous*, the latter *acetous* fermentation.

The principal substance concerned in vinous fermentation is sugar; and no vegetable juice can be made to undergo the process, which does not contain it in a very sensible quantity. In the production of beer, the sugar is derived from the malt; in that of wine, from the juice of the grape.

1856. In the manufacture of *beer*, the malt is ground and infused in the *mash-tun*, in rather more than its bulk of water, of the temperature of 160° or 180°. Here the mixture is stirred for a few hours; the liquor is then run off, and more water added, until the malt is exhausted. These infusions are called *wort*, and its principal contents are *saccharine matter*, *starch*, *mucilage*, and a small quantity of *gluten*. The strength of the wort is adjusted by its specific gravity, which is usually found by an instrument not quite correctly called a *saccharometer*, since it is influenced by all the contents of the wort, and not by the sugar only. It is a brass instrument, of the shape shown in the margin, so adjusted in weight as to sink to the point



marked 0°, in distilled water, at the temperature of 70°, and when immersed in a liquor of the same temperature, and of the specific gravity of 1.100, it is buoyed up to the mark 100, just above the bulb. The intermediate space is divided into 100 equal parts, and consequently will indicate intermediate degrees of specific gravity. This is the most useful form of the instrument, though not that in common use. The specific gravity of the wort for ale is usually about1.090 to 1.100, and for table-beer from 1.020 to 1.030.

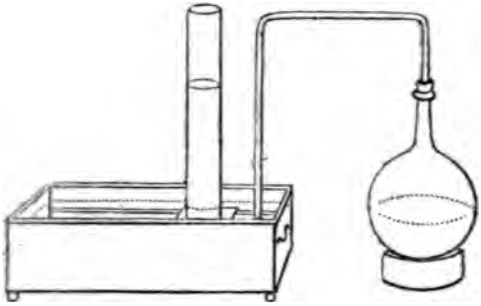
The wort is next boiled with hops, amounting, upon the average, to $\frac{1}{20}$ the weight of the malt, their use being to cover the sweetness of the liquor by their aromatic bitter, and to diminish its tendency to acidify. The liquor is then thrown into large, but very shallow, vessels, or *coolers*, where it is cooled to about 50°, as quickly as possible; it is then suffered to run into the *fermenting vat*, having been previously mixed with a proper quantity of *yeast*, which accelerates fermentation, apparently by virtue of the gluten which it contains.

In the fermenting vessel, the different substances held in solution in the liquor begin to act upon each other; an intestine motion ensues, the temperature of the liquor increases, carbonic acid escapes in large quantities; at length this evolution of gas ceases, the liquor becomes quiet and clear, and it has now lost much of its sweetness, has diminished in specific gravity, acquired a new flavour, and become intoxicating.

1857. The distillers prepare a liquor, called *wash*, for the express purpose of producing from it ardent spirits; instead of brewing this from pure malt, they chiefly employ raw grain, mixed with a small quantity only of malted grain; the water employed in the mash-tun is of a lower temperature than that requisite in brewing, and the mashing longer continued; by which it would appear that a part of the starch of the barley is rendered into a kind of saccharine matter. The wort is afterwards fermented with yeast.

1858. *Wine* is principally procured from the juice of the grape, and some other saccharine and mucilaginous juices of fruits. The principal substances held in solution in grape juice are, *sugar*, *gum*, *gluten*, and *bi-tartrate of potassa*. It easily ferments spontaneously at temperatures between 60° and 80°, and the phenomena it gives rise to closely resemble those of the wort with yeast. After the operation, its specific gravity is much diminished, its flavour changed, and it has acquired intoxicating powers.

1859. If a mixture of 1 part of sugar, 4 or 5 of water, and a little yeast, be placed in a due temperature, it also soon begins to ferment, and gives rise to the same products as wort or grape-juice; and, as the free admission of air is not necessary to vinous fermentation, its results may easily be examined by suffering the process to go on in the following apparatus; consisting of a matrass containing the fermenting mixture, with a bent tube issuing from it, and passing into an inverted jar standing in water.



It will thus be found that the only gaseous product is carbonic acid: and, consequently, that carbon and oxygen are the principles which the saccharine matter loses during the process.

1860. When any of the above-mentioned fermented liquors are distilled, they afford a *spirituous liquor*; that from wine is termed *brandy*; from the fermented juice of the sugar-cane we obtain *rum*; and from wash, *malt spirit*; and these spirituous liquors, by re-distillation, furnish *spirit of wine*, *ardent spirit*, or *alcohol*.

1861. The different fermented liquors furnish very different proportions of alcohol, and it has been sometimes supposed that it does not pre-exist to the amount in which it is obtained by distillation; but some experiments which I made upon the subject, in 1811 and 1813, and which are printed in the *Philosophical Transactions* for those years, tend to show that it is a real educt, and not formed by the action of heat upon the elements existing in the fermented liquor. The following Table exhibits the proportion of alcohol, specific gravity .825 at 60°, by measure, existing in 100 parts of several kinds of wine and other liquors:

	Proportion of Spirit per cent. by measure.
1. Lissa	26.47
Ditto	24.35
Average	25.41
2. Raisin wine	26.40
Ditto	25.77
Ditto	23.20
Average	25.12
3. Marsala	26.03
Ditto	25.05
Average	25.09
4. Port	25.83
Ditto	24.29
Ditto	23.71
Ditto	23.39
Ditto	22.30
Ditto	21.40
Ditto	19.00
Average	22.96
5. Madeira	24.42
Ditto	23.93
Ditto (Sercial)	21.40
Ditto	19.24
Average	22.27
6. Currant wine	20.55
7. Sherry	19.81
Ditto	19.83
Ditto	18.79
Ditto	18.25
Average	19.17
8. Teneriffe	19.79
9. Colares	19.75

	Proportion of Spirit per cent. by measure.
10. Lachryma Christi	19.70
11. Constantia, white	19.75
12. Ditto, red	18.92
13. Lisbon	18.94
14. Malaga	18.94
15. Bucellas	18.49
16. Red Madeira	22.30
Ditto	18.40
Average	20.35
17. Cape Muschat	18.25
18. Cape Madeira	22.94
Ditto	20.50
Ditto	18.11
Average	20.51
19. Grape wine	18.11
20. Calcavella	19.20
Ditto	18.10
Average	18.65
21. Vidonia	19.25
22. Alba Flora	17.26
23. Malaga	17.26
24. White Hermitage	17.43
25. Rousillon	19.00
Ditto	17.26
Average	18.13
26. Claret	17.11
Ditto	16.32
Ditto	14.08
Ditto	12.91
Average	15.10
27. Zante	17.05

	Proportion of Spirit per cent. by measure.
28. Malmsey Madeira	16.40
29. Lunel	15.52
30. Sheraaz	15.52
31. Syracuse	15.28
32. Sauterne	14.22
33. Burgundy	16.60
Ditto	15.22
Ditto	14.53
Ditto	11.95
Average	14.57
34. Hock	14.37
Ditto	13.00
Ditto (old in cask)	8.88
Average	12.08
35. Nice	14.63
36. Barsac	13.86
37. Tent	13.30
38. Champagne (still)	13.80
Ditto (sparkling)	12.80
Ditto (red)	12.56
Ditto (ditto)	11.30
Average	12.61
39. Red Hermitage	12.32
40. Vin de Grave	13.94
Ditto	12.80
Average	13.37
41. Frontignac (Rivesalte)	12.79
42. Cote Rotie	12.32
43. Gooseberry wine	11.84
44. Orange wine—average of 6 samples made by a London manufacturer	11.26

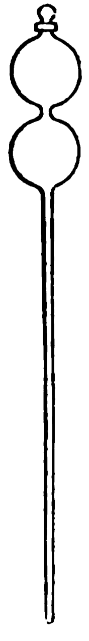
	Proportion of Spirit per cent. by measure.
45. Tokay	9.88
46. Elder wine	8.79
47. Cider, highest average .	9.87
Ditto, lowest ditto . .	5.21
48. Perry, average of 4 samp.	7.26
49. Mead	7.32
50. Ale (Burton) . . .	8.88
Ditto (Edinburgh) . .	6.20
Ditto (Dorchester) . .	5.56
Average .	6.87
51. Brown Stout	6.80
52. London Porter (average)	4.20
53. Ditto small beer (ditto)	1.28
54 Brandy	53.39
55. Rum	53.68
56. Gin	51.60
57. Scotch Whiskey . . .	54.32
58. Irish ditto	53.90

1862. The principle upon which the intoxicating properties of fermented liquors depends, and which exists in ardent spirits, is in its purest form called *alcohol.* It may be obtained by distilling the *rectified spirit of wine* of commerce, with one-fourth of its weight of dry and warm carbonate of potassa; about three-fourths may be drawn over. There are other substances which may be used as substitutes for the carbonate, especially muriate of lime.

1863. Alcohol thus obtained by slow and careful distillation, is a limpid, colourless liquid, of an agreeable smell, and a strong pungent flavour. Its specific gravity varies with its purity; the purest obtained by rectification over muriate of lime being .791; as it usually occurs it is .820 at 60°. If rendered as pure as possible by simple distillation, it can scarcely be obtained of a lower specific gravity than .825, at 60°.

1864. Alcohol has never been frozen, and consequently is particularly useful in the construction of thermometers intended to measure intense degrees of cold. When of a specific gravity of .825, it boils at the temperature of 176°, the barometrical pressure being 30 inches. In the vacuum of an air-pump it boils at common temperatures. The specific gravity of the vapour of alcohol, compared with atmospheric air, is 1.613.—Gay-Lussac, *Annales de Chimie et Phys.* Tom. i.

1865. Alcohol may be mixed in all proportions, with water, and the specific gravity of the mixture is greater than the mean of the two liquids, in consequence of a diminution of bulk that occurs on mixture, as may be shewn by the following experiment:



The annexed wood-cut represents a tube with two bulbs, communicating with each other, the upper one being supplied with a well-ground glass stopper. Fill the tube and lower bulb with water, pour alcohol slowly into the upper bulb, and when full put in the stopper. The vessel will now be completely filled, the alcohol lying upon the water; if it be inverted, the alcohol and water will slowly mix, and the condensation that ensues will be indicated by the empty space in the tube. A considerable rise of temperature takes place in this experiment, in consequence of the condensation.

1866. The strength of such spirituous liquors as consist of little else than water and alcohol, is of course ascertained by their specific gravity ; and for the purpose of levying duties upon them, this is ascertained by the hydrometer ; an instrument constructed upon the same principle as that described at page 129. But the only correct mode of ascertaining the specific gravity of liquids, is by weighing them in a delicate balance, against an equal volume of pure water, of a similar temperature (507).

1867. In the *Philosophical Transactions* for 1794, Mr. Gilpin has given a copious and valuable series of tables of the specific gravity of mixtures of alcohol and water, and of the condensation that ensues, with several other particulars. These are extremely useful, as enabling us to ascertain, without difficulty, the relative quantity of alcohol contained in any mixture of known specific gravity.

The original tables are extremely voluminous, and have been variously abridged by different persons ; I have, however, thought it most useful to insert two of them, adapted to the temperature of 60°, and refer the reader to Mr. Gilpin's paper for those calculated at other temperatures.

TABLE

Of the Specific Gravity and Composition of Mixtures of Alcohol and Water at the Temperature of 60°.

I. Spirit and Water by Weight.	II. Specific Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit *per Cent.* by Measure.
Sp.+W.						
100+ 0	.82500	100	—	100.00	—	100.00
1	.82731	—	0.83	100.72	0.11	99.29
2	.82957	—	1.65	101.44	0.21	98.58
3	.83177	—	2.47	102.16	0.31	97.88
4	.83391	—	3.30	102.89	0.41	97.19
100+ 5	.83599	—	4.12	103.62	0.50	96.51
6	.83802	—	4.95	104.35	0.60	95.83
7	.84001	—	5.77	105.09	0.68	95.16
8	.84195	—	6.60	105.83	0.77	94.50
9	.84384	—	7.42	106.57	0.85	93.84
100+10	.84568	—	8.25	107.31	0.94	93.19
11	.84748	—	9.07	108.05	1.02	92.55
12	.84924	—	9.90	108.80	1.10	91.91
13	.85096	—	10.72	109.55	1.17	91.28
14	.85265	—	11.55	110.30	1.25	90.66
100+15	.85430	—	12.37	111.05	1.32	90.04
16	.85592	—	13.20	111.81	1.39	89.44
17	.85750	—	14.02	112.56	1.46	88.84
18	.85906	—	14.85	113.32	1.53	88.25
19	.86058	—	15.67	114.08	1.59	87.66
100+20	.86208	—	16.50	114.84	1.66	87.08
21	.86355	—	17.32	115.60	1.72	86.51
22	.86500	—	18.15	116.36	1.79	85.94
23	.86642	—	18.97	117.12	1.85	85.38
24	.86781	—	19.80	117.88	1.92	84.83
100+25	.86918	—	20.62	118.64	1.98	84.28
26	.87052	—	21.45	119.41	2.04	83.74
27	.87183	—	22.27	120.18	2.09	83.21
28	.87314	—	23.10	120.94	2.16	82.68
29	.87442	—	23.92	121.71	2.21	82.16

I. Spirit and Water by Weight. Sp.+W.	II. Specific Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit *per Cent.* by Measure.
100+30	.87569	100	24.75	122.48	2.27	81.65
31	.87692	—	25.57	123.24	2.33	81.14
32	.87814	—	26.40	124.01	2.39	80.64
33	.87935	—	27.22	124.78	2.44	80.14
34	.88053	—	28.05	125.55	2.50	79.65
100+35	.88169	—	28.87	126.32	2.55	79.16
36	.88283	—	29.70	127.09	2.61	78.68
37	.88395	—	30.52	127.86	2.66	78.21
38	.88505	—	31.35	128.64	2.71	77.74
39	.88613	—	32.17	129.41	2.76	77.27
100+40	.88720	—	33.00	130.19	2.81	76.81
41	.88825	—	33.82	130.96	2.86	76.36
42	.88929	—	34.65	131.74	2.91	75.91
43	.89032	—	35.47	132.51	2.96	75.47
44	.89133	—	36.30	133.29	3.01	75.03
100+45	.89232	—	37.12	134.06	3.06	74.59
46	.89330	—	37.95	134.84	3.11	74.16
47	.89427	—	38.77	135.61	3.16	73.74
48	.89522	—	39.60	136.39	3.21	73.32
49	.89615	—	40.42	137.17	3.25	72.90
100+50	.89707	—	41.25	137.95	3.30	72.49
51	.89797	—	42.07	138.73	3.34	72.08
52	.89886	—	42 90	139.51	3.39	71.68
53	.89973	—	43.72	140.29	3.43	71.28
54	.90059	—	44.55	141.07	3.48	70.89
100+55	.90144	—	45.38	141.86	3.52	70.49
56	.90227	—	46.20	142.64	3.56	70.11
57	.90309	—	47.02	143.42	3.60	69.72
58	.90391	—	47.85	144.21	3.64	69.34
59	.90470	—	48.67	144.99	3.68	68.97
100+60	.90549	—	49.50	145.78	3.72	68.60
61	.90626	—	50.32	146.56	3.76	68.23
62	.90703	—	51.15	147.35	3.80	67.87
63	.90778	—	51.97	148.13	3.84	67.51
64	.90853	—	52.80	148.92	3.88	67.15

TABLE

Of the Specific Gravity and Composition of Mixtures of Alcohol and Water at the Temperature of 60°.

I. Spirit and Water by Weight. Sp.+W.	II. Specific Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit per Cent. by Measure.
100+ 0	.82500	100	—	100.00	—	100.00
1	.82731	—	0.83	100.72	0.11	99.29
2	.82957	—	1.65	101.44	0.21	98.58
3	.83177	—	2.47	102.16	0.31	97.88
4	.83391	—	3.30	102.89	0.41	97.19
100+ 5	.83599	—	4.12	103.62	0.50	96.51
6	.83802	—	4.95	104.35	0.60	95.83
7	.84001	—	5.77	105.09	0.68	95.16
8	.84195	—	6.60	105.83	0.77	94.50
9	.84384	—	7.42	106.57	0.85	93.84
100+10	.84568	—	8.25	107.31	0.94	93.19
11	.84748	—	9.07	108.05	1.02	92.55
12	.84924	—	9.90	108.80	1.10	91.91
13	.85096	—	10.72	109.55	1.17	91.28
14	.85265	—	11.55	110.30	1.25	90.66
100+15	.85430	—	12.37	111.05	1.32	90.04
16	.85592	—	13.20	111.81	1.39	89.44
17	.85750	—	14.02	112.56	1.46	88.84
18	.85906	—	14.85	113.32	1.53	88.25
19	.86058	—	15.67	114.08	1.59	87.66
100+20	.86208	—	16.50	114.84	1.66	87.08
21	.86355	—	17.32	115.60	1.72	86.51
22	.86500	—	18.15	116.36	1.79	85.94
23	.86642	—	18.97	117.12	1.85	85.38
24	.86781	—	19.80	117.88	1.92	84.83
100+25	.86918	—	20.62	118.64	1.98	84.28
26	.87052	—	21.45	119.41	2.04	83.74
27	.87183	—	22.27	120.18	2.09	83.21
28	.87314	—	23.10	120.94	2.16	82.68
29	.87442	—	23.92	121.71	2.21	82.16

I. Spirit and Water by Weight. Sp. + W.	II. Specific Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit *per Cent.* by Measure.
100+30	.87569	100	24.75	122.48	2.27	81.65
31	.87692	—	25.57	123.24	2.33	81.14
32	.87814	—	26.40	124.01	2.39	80.64
33	.87935	—	27.22	124.78	2.44	80.14
34	.88053	—	28.05	125.55	2.50	79.65
100+35	.88169	—	28.87	126.32	2.55	79.16
36	.88283	—	29.70	127.09	2.61	78.68
37	.88395	—	30.52	127.86	2.66	78.21
38	.88505	—	31.35	128.64	2.71	77.74
39	.88613	—	32.17	129.41	2.76	77.27
100+40	.88720	—	33.00	130.19	2.81	76.81
41	.88825	—	33.82	130.96	2.86	76.36
42	.88929	—	34.65	131.74	2.91	75.91
43	.89032	—	35.47	132.51	2.96	75.47
44	.89133	—	36.30	133.29	3.01	75.03
100+45	.89232	—	37.12	134.06	3.06	74.59
46	.89330	—	37.95	134.84	3.11	74.16
47	.89427	—	38.77	135.61	3.16	73.74
48	.89522	—	39.60	136.39	3.21	73.32
49	.89615	—	40.42	137.17	3.25	72.90
100+50	.89707	—	41.25	137.95	3.30	72.49
51	.89797	—	42.07	138.73	3.34	72.08
52	.89886	—	42 90	139.51	3.39	71.68
53	.89973	—	43.72	140.29	3.43	71.28
54	.90059	—	44.55	141.07	3.48	70.89
100+55	.90144	—	45.38	141.86	3.52	70.49
56	.90227	—	46.20	142.64	3.56	70.11
57	.90309	—	47.02	143.42	3.60	69.72
58	.90391	—	47.85	144.21	3.64	69.34
59	.90470	—	48.67	144.99	3.68	68.97
100+60	.90549	—	49.50	145.78	3.72	68.60
61	.90626	—	50.32	146.56	3.76	68.23
62	.90703	—	51.15	147.35	3.80	67.87
63	.90778	—	51.97	148.13	3.84	67.51
64	.90853	—	52.80	148.92	3.88	67.15

I. Water and Spirit by Weight. W. + Sp.	II. Specific Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit per Cent. by Measure.
100+65	.94876	100	126.92	220.74	6.18	45.30
64	.94936	—	128.90	222.69	6.21	44.91
63	.94997	—	130.95	224.70	6.25	44.50
62	.95058	—	133.06	226.78	6.28	44.10
61	.9511	—	135.25	228.93	6.32	43.68
100+60	.95181	—	137.50	231.14	6.36	43.26
59	.95243	—	139.82	233.44	6.38	42.84
58	.95305	—	142.23	235.82	6.41	42.41
57	.95368	—	144.73	238.28	6.45	41.97
56	.95430	—	147.32	240.82	6.50	41.52
100+55	.95493	—	150.00	243.47	6.53	41.07
54	.95555	—	152.77	246.22	6.55	40.61
53	.95617	—	155.65	249.08	6.57	40.15
52	.95679	—	158.65	252.05	6.60	39.67
51	.95741	—	161.77	255.14	6.63	39.19
100+50	.95804	—	165.00	258.34	6.66	38.71
49	.95867	—	168.37	261.68	6.69	38.21
48	.95931	—	171.87	265.16	6.71	37.71
47	.95995	—	175.53	268.80	6.73	37.20
46	.96058	—	179.35	272.59	6.76	36.68
100+45	.96122	—	183.34	276.56	6.78	36.16
44	.96185	—	187.50	280.70	6.80	35.63
43	.96248	—	191.86	285.05	6.81	35.08
42	.96311	—	196.43	289.60	6.88	34.53
41	.96374	—	201.21	294.38	6.88	33.97
100—40	.96437	—	206.25	299.42	6.83	33.40
39	.96500	—	211.54	304.71	6.83	32.82
38	.96563	—	217.10	310.28	6.82	32.23
37	.96626	—	222.97	316.15	6.82	31.63
36	.96689	—	229.17	322.36	6.81	31.02
109+35	.96752	—	235.71	328.90	6.81	30.40
34	.96816	—	242.65	335.84	6.81	29.78
33	.96880	—	250.00	343.21	6.79	29.14
32	.96944	—	257.81	351.04	6.77	28.49
31	.97009	—	266.13	359.38	6.75	27.83

I. Water and Spirit by Weight. W. + Sp.	II. Specific .Gravity.	III. Spirit by Measure.	IV. Water by Measure.	V. Bulk of Mixture.	VI. Diminution of Bulk.	VII. Quantity of Spirit *per Cent.* by Measure.
100+30	.97074	100	275.00	368.28	6.72	27.15
29	.97139	—	284.48	377.79	6.69	26.47
28	.97206	—	294.64	387.99	6.65	25.77
27	.97273	—	305.56	398.95	6.61	25.07
26	.97340	—	317.31	410.74	6.57	24.35
100+25	.97410	—	330.00	423.48	6.52	23.61
24	.97479	—	343.75	437.29	6.46	22.87
23	.97550	—	358.70	452.31	6.39	22.11
22	.97622	—	375.00	468.64	6.36	21.34
21	.97696	—	392.86	486.58	6.28	20.55
100+20	.97771	—	412.50	506.29	6.21	19.75
19	.97848	—	434.21	528.08	6.13	18.94
18	.97926	—	458.33	552.29	6.04	18.11
17	.98006	—	485.29	579.34	5.95	17.26
16	.98090	—	515.62	609.76	5.86	16.40
100+15	.98176	—	550.00	644.25	5.75	15.52
14	.98264	—	589.29	683.66	5.63	14.63
13	.98356	—	634.61	729.10	5.51	13.72
12	.98452	—	687.50	782.11	5.39	12.79
11	.98551	—	750.00	844.74	5.26	11.84
100+10	.98654	—	825.00	919.87	5.13	10.87
9	.98761	—	916.67	1011.70	4.97	9.88
8	.98872	—	1031.25	1126.44	4.81	8.88
7	.98991	—	1178.57	1273.92	4.65	7.85
6	.99115	—	1375.00	1470.52	4.48	6.80
100 + 5	.99244	—	1650 00	1745.70	4.30	5.73
4	.99380	—	2062.50	2158.37	4.13	4.63
3	.99524	—	2750.00	2846.04	3.96	3.51
2	.99675	—	4125 00	4221.21	3.79	2.37
1	.99834	—	8250.00	8346.38	3.62	1.20

1868. There are other methods of judging of the strength of spirituous liquors, which, though useful are not accurate, such as the taste, the size and appearance of the bubbles when shaken, the sinking or floating of olive oil in it, and the appearances that it exhibits when burned; if it burns away perfectly to dryness, and inflames gunpowder or a piece of cotton immersed in it, it is considered as alcohol; the different spirituous liquors leave variable proportions of water, when thus burned in a graduated vessel.

1869. There is the greatest difficulty in ascertaining what is meant by the term *proof spirit.* Dr. Thomson, quoting the Act of Parliament of 1762 (*System*, ii. 319,) states, that at the temperature of 60°, the specific gravity of proof spirit should be 0.916; and he also observes, that *proof spirit* usually means a mixture of *equal bulks* of alcohol and water; but the specific gravity of such a mixture will, of course, depend upon that of the standard alcohol, which is not specified. It appears from GILPIN's *Tables*, that spirit of the specific gravity .916, at 60°, consists, *by weight*, of 100 parts of alcohol, specific gravity .825, at 60°, and 75 of water; and, *by measure*, of 100 parts of the same alcohol, and 61.87 of water. From the *Tables* of LOWITZ, quoted by Dr. Thomson, from CRELL's *Annals* (1796, i. 202,) we learn, that equal weights of alcohol, specific gravity .796, at 60°, (and which may be regarded as *pure alcohol*,) and water, have a specific gravity of .917, which is very near legal proof, and which, according to GILPIN's *Tables*, contains 62.8 parts *per cent.* of his alcohol, *by measure.*

1870. Alcohol is extremely inflammable, and burns with a pale blue flame, scarcely visible in bright day-light. It occasions no fuliginous deposition upon substances held over it, and the products of its combustion are carbonic acid and water, the weight of the water considerably exceeding that of the alcohol consumed. According to Saussure, jun., 100 parts of alcohol afford, when burned, 136 parts of water, the production of which may be shown by substituting the flame of alcohol for that of water, in the apparatus described in the first volume, under the Article WATER (236, i.), and if the tube at its extremity be turned down into a glass jar, it will be found that a current of carbonic acid passes out of it, which may be rendered evident by lime-water.

There are some substances which communicate colour to the flame of alcohol; from boracic acid it acquires a greenish-yellow tint; nitre and the soluble salts of baryta cause it to burn yellow, and those of strontia give it a beautiful rose colour; cupreous salts impart a fine green tinge.

1871. Alcohol dissolves pure soda and potassa, but it does not act upon their carbonates: consequently, if the latter be mixed with alcohol containing water, the liquor separates into two portions, the upper being alcohol deprived to a considerable extent, of water, and the lower the aqueous solution of the carbonate. The alcoholic solution of caustic potassa was known in old pharmacy, under the name of Van Helmont's *Tincture of Tartar.* Its use in purifying potassa has already been stated (544); if it be long kept it deposits small crystals of carbonate of potassa, and becomes nearly black, from the decomposition of a portion of alcohol. Ammonia and the carbonate are both soluble in alcohol; the greater number of the sulphates are insoluble in this menstruum, but it dissolves many of the muriates and nitrates. It also dissolves the greater number of the acids. It absorbs many gaseous bodies. It dissolves the vegetable acids, the volatile oils, the resins, tan, and extractive matter, and many of the soaps; the greater number of the fixed oils are taken up by it in small quantities only, but some dissolve largely. It may be remarked, that many errors exist in the published estimates of the solubility of substances in alcohol, arising from the existence of water either in the solvent or substance dissolved.

1872. When the vapour of alcohol is passed through a red-hot copper tube, it is decomposed, a portion of charcoal is deposited, and a large quantity of carburetted hydrogen gas is evolved.

The most satisfactory experiments on the composition of alcohol are those of Saussure, as quoted by Dr. Thomson (*System*, ii. p. 327). He passed the alcohol through a red-hot porcelain tube, terminating in a glass tube six feet long and surrounded by ice; all the products were carefully collected and weighed. The result of this analysis was, that 100 parts of pure alcohol consist of

Hydrogen	13.70
Carbon	51.98
Oxygen	34.32
	100.00

These numbers approach to 3 proportionals of hydrogen, = 3; 2 of carbon, = 11.4; and 1 of oxygen, = 7.5.

Or it may be regarded as composed of

Olefiant gas	61.63
Water	38.37
	100.00

If we consider it as composed of 1 volume of olefiant gas, and 1 volume of the vapour of water, the 2 volumes being condensed into 1, the specific gravity of the vapour of alcohol, compared with common air, will be 1.599, or, according to Gay-Lussac, 1.613.

1873. When alcohol is submitted to distillation, with certain acids, a peculiar compound is formed, called *ether*, the different ethers being distinguished by the name of the acid employed in their preparation.

a. SULPHURIC ETHER.

1874. *Sulphuric Ether* is the most important of these compounds; it is prepared as follows: Equal weights of alcohol and sulphuric acid are carefully mixed and introduced into a glass-retort placed in a sand-bath, to which is adapted a capacious tubulated glass globe, connected with a receiver, as represented in the wood-cut at page 353, Vol. I. Raise the mixture in the retort to its boiling point as rapidly as possible, and, keeping the receiver cool by water or ice, continue the distillation, till opaque vapours appear in the retort; then remove the receiver, and agitate its contents with a little quick-lime; after which pour off the clear liquor, and re-distil to the amount of three-fourths its original quantity with the same precautions as before. The ether may be further purified by distilling it off muriate of lime. The *London Pharmacopœia* directs the distillation of ether with potassa, for its purification from sulphurous acid; and Mr. Richard Phillips, in his *Experimental Examination*, has given the following directions for procuring ether for pharmaceutical purposes, which answer extremely well. "Mix with 16 ounces of sulphuric acid, an equal weight of rectified spirit, and distil about 10 fluid ounces, add 8 ounces of spirit to the residuum in the retort, and distil about 9 fluid ounces; or continue the operation until the contents of the retort begin to rise or the product becomes considerably sulphurous; mix the two products, and if the mixture consist of a light and heavy fluid, separate them: add potash to the lighter, as long as it appears to be dissolved; separate the ether from the solution of potash, and distil about nine-tenths of it, to be preserved as *ether sulphuricus*, the specific gravity of which ought to be at most .750."

1875. Preparing ether upon a large scale, it is found that 14 parts of alcohol (specific gravity .820) mixed with an equal weight of sulphuric acid (specific gravity 1.8,) and submitted to distillation, afford about 8 parts of impure ether (specific gravity .770). To the residuum 7 parts of alcohol may be added, and about 7¾ parts more of impure ether drawn off. These products, when mixed, have a specific gravity of about .782, and when rectified by distillation on carbonate of potassa, afford 10¼ parts of ether, of a specific gravity of .735, and about 3½ parts of ethereal spirit, which is employed instead of an equal quantity of alcohol in the next operation.

1876. When ether, obtained by the usual process, is washed with its bulk of water, its specific gravity is diminished, and the water employed for washing it affords, on distillation, a considerable portion of alcohol. By re-distilling this washed ether with a little potassa, which keeps down the water, or by treating it with muriate of lime, it is obtained extremely light and pure.

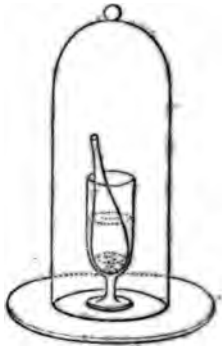
1877. Sulphuric ether is a transparent, colourless liquid, of a pleasant smell and a pungent taste; it is highly exhilarating, and produces a degree of intoxication when its vapour is inhaled by the nostrils. Its specific gravity varies extremely with its purity. Lowitz is said to have procured it as light as .632. I have never obtained it lower than .700: and, as ordinarily prepared, its specific gravity varies between .730 and .760.

It is extremely volatile, and when poured from one vessel into another, a considerable portion evaporates, during its evaporation from surfaces, it produces intense cold, as may be felt by pouring it upon the hand; and seen, by dropping it upon the bulb of a thermometer, which sinks to many degrees below the freezing point (91). The sp. gr. of the vapour of sulphuric ether, compared with atmospheric air, is, according to Gay-Lussac, as 2.586 to 1.000.

At mean pressure, sulphuric ether, when of a specific gravity of .720, boils at 98°, and under the exhausted receiver of the air-pump, at all temperatures above

−20°; hence, were it not for atmospheric pressure, ether would only be known in the state of vapour.

In consequence of the cold produced during the vaporization of sulphuric ether, the phænomena of boiling and freezing may be exhibited in the same vessel. For this purpose procure a very thin flask which fits loosely into a wine-glass, as shown in the margin. Pour a small quantity of ether into the flask, and of water into the glass, and place the whole under the receiver of an air-pump; during exhaustion, the ether will boil, and a crust of ice will gradually form upon the exterior of the flask.



When subjected to a degree of cold equal to −46°, sulphuric ether freezes.

1878. Ether dissolves the resins, several of the fixed oils, and nearly all the volatile oils; it also dissolves a portion of sulphur, and of phosphorus; the latter solution is beautifully luminous when poured upon warm water, in a dark room. The fixed alcalis are not soluble in ether, but it combines with ammonia.

Ether dissolves the oxides of gold and platinum, and these solutions have been employed for coating steel with those metals, with a view to ornament and as a defence from rust. If to a saturated solution of gold or platinum, in nitro-muriatic acid, there be added about 3 parts by measure of good sulphuric ether, it soon takes up the metals, leaving the acid nearly colourless below the ethereal solution, which is to be carefully decanted off; into this the polished steel is for an instant plunged, and immediately afterwards washed in water, or in a weak alcaline solution. Though the coating of platinum is the least beautiful, Mr. Stodart, who has made many experiments upon this subject, considers it as the best protection from rust. Polished brass may be coated by the same process. These surfaces of gold and platinum, though very thin, are often a useful protection: with gold the experiment is particularly beautiful, and well illustrates the astonishing divisibility of the metal. The ethereal solution of gold is not permanent, but, after a time, deposits the metal in the form of a film, in which crystals of gold are often perceptible.

1879. Ether is sparingly soluble in water, and in alcohol it dissolves in all proportions. The *spiritus ætheris sulphurici* of the *Pharmacopæia*, is an alcoholic solution of ether.

1880. Ether is highly inflammable, and in consequence of its volatility it is often kindled by the mere approach of a burning body; a circumstance which renders it highly dangerous to decant, or open vessels of ether near a candle.

The inflammability of ethereal vapour may be shown by passing a small quantity into a receiver, furnished with a brass stop-cock and pipe, and inverted over water at the temperature of 100°. The receiver becomes filled with the vapour, which may be propelled and inflamed; it burns with a bright bluish white flame.

1881. When ether is admitted to any gaseous body it increases its bulk. Oxygen thus expanded, produces a highly inflammable mixture; if the quantity of oxygen be large, and of ether small, the mixture is highly explosive, and produces water and carbonic acid.

1882. When the vapour of ether is passed through a red-hot tube, it is decomposed, and furnishes a large quantity of carburetted hydrogen gas. Its analysis has been performed in various ways ; M. Saussure, by detonating ethereal vapour with oxygen, and ascertaining the quantity of carbonic acid formed, and that of oxygen consumed, is led to consider the component parts of ether as,

Hydrogen	14.40
Carbon	67.98
Oxygen	17.62
	100.00

which proportions are equivalent to

Olefiant gas	100
Water	25

Or, it may be stated as consisting of

5	proportionals of	olefiant gas,	6.7 × 5=33.5
1	,,	water ,,	= 8.5
			42.0

which numbers, reduced to ultimate components, give

6	proportionals of	hydrogen..	1 × 6= 6.
5	,,	carbon....	5.7 × 5=28.5
1	,,	oxygen ..——	= 7.5
			42.0

1883. By reverting to the composition of alcohol, the change effected upon it by the sulphuric acid in the process of etherification will be evident, as also the rationale of the production of olefiant gas (421). Alcohol consists of

Olefiant gas	100
Water	50

If we now remove the whole of the water, which may be effected by a due proportion of sulphuric acid, we obtain olefiant gas only; but, if we only abstract half the water, we convert the alcohol into ether; not that either of these conversions are ever perfectly performed in any of our processes.

1884. When a little ether is introduced into chlorine, the gas is absorbed, and a peculiar compound results, in which muriatic acid is very perceptible; if the ether be inflamed, a large quantity of charcoal is deposited, and muriatic acid gas is abundantly evolved.

1885. If ether be mixed with its bulk of sulphuric acid, and submitted to distillation, a portion of it is converted into a peculiar fluid, which has been termed *oil of wine;* it is the *oleum æthereum* of the *Pharmacopœia.* It has a sweetish taste, and a rich agreeable odour. It does not mix with water, but readily dissolves in ether and in alcohol. It is very inflammable, and deposits a large quantity of carbon during its combustion. Its composition has not been inquired into.

1886. The residue of the distillation of ether has been examined by several chemists. According to Sertuerner, new acid compounds are produced, which he calls *œnothionic acids.* (THOMSON'S *Annals*, xiv. 44.) M. Vogel, in repeating these experiments, allows the formation of one new acid only, which he calls *sulpho-*

vinous acid: he obtained it by saturating the residue of the distillation of ether with carbonate of lead; the liquor being filtered, contained a soluble *sulphovinate of lead;* sulphuretted hydrogen passed through this solution precipitated the lead and left the pure acid, which is so easily decomposed by heat as only to admit of concentration by evaporation under the exhausted receiver.

1887. *Sulphovinate of Baryta* was obtained by Gay-Lussac, in rhomboidal prisms terminated by a rhomboidal pyramid; the crystals were transparent, and permanent, but easily decomposed by heat.

1888. A strong analogy appears to subsist between the hyposulphuric and sulphovinous acids; and it will probably be found that the latter derives its peculiarities from the combination of a portion of ethereal oil.—*Annales de Chimie,* xiii. *Quarterly Journal of Science and Arts,* ix. 397.

1889. When ether is passed over red-hot platinum wire, or consumed in the lamp without flame, described in the Chapter on Radiant Matter (191), a peculiar acid substance is produced, which has been subjected to an interesting series of experiments, by Mr. J. F. Daniell, (*Quarterly Journal of Science and Arts,* vi. 318.) He obtained it by placing the lamp, filled with ether, and properly trimmed with a coil of glowing platinum wire, under the head of an alembic, in which the vapour was condensed, and collected in a phial applied to its beak.

Lampic acid, for so Mr. Daniell has termed this product, is colourless, sour, and pungent; its vapour is very irritating, and its specific gravity, when purified by carefully driving off a portion of alcohol which it contains, is about 1.015. It reddens vegetable blues, and decomposes the alcaline carbonates with effervescence.

Mr. Daniell has described many of the combinations of this acid, which he terms *lampates*, and has given some experiments upon its composition, whence he deduces its ultimate components, as follow:

1	proportional carbon	5.7
1	———— hydrogen ...	1.
1	———— water	8.5
		15.2

When lampic acid is added to the solutions of silver, gold, platinum, mercury, and copper, and the mixture heated, the metals are thrown down in the metallic state.

On distilling the *lampate of mercury*, made by digesting the peroxide of mercury in the acid, Mr. Daniell obtained the concentrated or pure lampic acid, in the form of a very dense liquid with an intensely suffocating odour.

b. NITRIC ETHER.

1890. When strong nitric acid and alcohol are mixed in equal proportions, a violent action presently ensues; there is a very copious evolution of an inflammable aëriform body, which has been called *nitrous etherized gas*, and which appears to be a compound of nitrous ether, and nitric oxide. If we endeavour to condense the volatile products, we find that the receiver contains alcohol, water, nitrous ether, nitrous acid, and acetic acid; and that the greater portion of the true ether has made its escape with the gaseous products. Thenard has paid much attention to this subject, and has given the following process for obtaining nitric ether (*Mémoires d'Arcueil*, Tom. i., and *Traité de Chimie*, Tom. iii., p. 278.):

Introduce into a sufficiently capacious retort equal weights of alcohol, (specific gravity 820) and of nitric acid of commerce (specific gravity 1.30) and connect it with five Wolfe's bottles, the first of which is empty, and the remaining four half-filled with a saturated solution of salt in water. Apply a gentle heat to the retort, till the liquor begins to effervesce; then withdraw the fire, and the gaseous matter passing through the bottles, which should be kept cold by ice, deposits the ether upon the saline solution, from which it is to be decanted, shaken with chalk, and re-distilled at a very gentle heat.

1891. Nitric ether, thus prepared, has the following properties: It has a very powerful ethereal odour; its colour is pale yellow; its taste very pungent; its specific gravity above that of alcohol, but less than that of water. It is more volatile than sulphuric ether, and the heat of the hand is sufficient to produce its ebullition. It is soluble in 48 parts of water; and in all proportions in alcohol; this last solution is the *spiritus ætheris nitrici*, or *sweet spirit of nitre*, of the *Pharmacopœia*. It is decomposed by keeping, and nitric and acetic acids are formed in it. According to Thenard, nitric ether consists of

Oxygen	48.52
Carbon	28.45
Nitrogen	14.49
Hydrogen	8.54
	100.00

Dr. Thomson (*System*, Vol. ii., p. 341.) concludes, from analogy, that nitric ether consists of 4 proportionals of olefiant gas, = 26.8, and 1 of nitric acid, = 50.5; or, of

4	proportionals of hydrogen	1 × 4 =	4.
4	——— carbon	5.7 × 4 =	22.8
1	——— nitrogen		13.
5	——— oxygen	7.5 × 5 =	37.5
			77.3

1892. When nitric acid, holding mercury or silver in solution, is added to alcohol, a white precipitate is formed during the effervescence that ensues, which is possessed of powerful detonating properties.

Fulminating Mercury was discovered by Mr. Howard, who has given the following directions for its preparation: Dissolve 100 grains of mercury, in a measured ounce and a half of nitric acid, by the assistance of a gentle heat; pour this solution into two measured ounces of alcohol, previously put into an evaporating basin, and apply a gentle heat till an effervescence ensues; when this has ceased, pour the liquid off the precipitate which falls, collect it upon a filter, wash it with a small quantity of water, and dry it at a heat not exceeding 212°.

Fulminating mercury thus prepared is in the form of small crystalline grains, of a whitish yellow or pale gray colour. A few grains placed on a smooth anvil and struck with a hammer, detonate with a sharp stunning report; it also explodes by friction, heat, and electricity; and by the action of concentrated sulphuric acid, though with less noise.

Mr. Howard considers this powder as a compound of oxalate of mercury and nitrous etherized gas: Fourcroy, however, has shown that its composition varies a little, under different circumstances of preparing it.—Howard, *Phil. Trans.*, 1800.

1893. By a similar process nearly, a species of *fulminating silver* may be prepared. (Descotils, Nicholson's *Journal*, Vol. xviii.) Upon three drachms of powdered nitrate of silver, pour two ounces and a half of alcohol, and add seven drachms, by measure, of nitric acid. When the effervescence has nearly ceased add a little water, wash the precipitate, and dry it in the open air, secluded from light.—Accum's *Chemical Amusement*, 3d edit., p. 102.

This very dangerous compound explodes upon slight friction, or when gently heated, or touched with sulphuric acid; and, upon the contact of a sharp piece of glass or rock crystal, it detonates even under water; an electric spark also occasions its explosion.

When exploded under slight pressure in contact of gunpowder, it inflames it.

The composition of this species of fulminating silver has not been ascertained with precision; indeed, the subject is one of extreme difficulty, in consequence of the new products that are formed by its sudden decomposition.

c. MURIATIC ETHER.

1894. Muriatic ether was thus obtained by Thenard, (*Mémoires d'Arcueil*, Tom. i.): Equal measures of strong liquid muriatic acid, and highly rectified alcohol, are put into a retort communicating with a receiver, from which a tube passes into a Wolfe's bottle containing warm water, and having a tube of safety: from this there issues a bent tube passing into a bottle surrounded by ice. On applying heat to the retort, a portion of alcohol and acid pass into the first receiver, and the ether in a gaseous state escapes through the warm water and the bent tube, and is condensed in the cold vessel.

1895. At a temperature somewhat below 70° muriatic ether passes into the state of vapour, of which the sp. gr. is about 2.220, that of air being 1.000; it is highly inflammable, its taste sweetish and ethereal, and it is soluble in its own bulk of water at 64°. Its specific gravity in a liquid state, at 40°, is .870. It is remarkable that this ether does not affect vegetable blues, nor does it afford traces of chlorine to the usual tests; but, when burned, muriatic acid is immediately perceptible.

1896. According to Thenard, this ether, contains

Muriatic acid	29.44
Carbon	36.61
Oxygen	23.31
Hydrogen	10.64
	100.00

Dr. Thomson considers muriatic ether as a compound of four proportionals of olefiant gas, and one of muriatic acid; hence it would contain

5	proportionals of hydrogen	1 × 5 =	5.
4	———— carbon	5.7 × 4 =	22.8
1	———— chlorine	....	33.5
			61.3

d. Hydriodic Ether.

1897. By distilling two measures of alcohol, with one of concentrated liquid hydriodic acid, Gay-Lussac obtained an ethereal liquid, of a specific gravity of 1.920 at 72°, and requiring a temperature of 148° for its ebullition. Its properties have not been very satisfactorily investigated, nor have any accurate experiments demonstrated its composition.—*Annales de Chimie*, xci.

Acetous Fermentation.

1898. When any of the vinous liquors are exposed to the free access of atmospheric air at a temperature of 80° or 85°, they undergo a second fermentation, terminating in the production of a sour liquid, called *vinegar*. During this process a portion of the oxygen of the air is converted into carbonic acid; hence, unlike vinous fermentation, the contact of the atmosphere is necessary, and the most obvious phænomenon is the removal of carbon from the beer or wine; the vinegar of this country is usually obtained from malt liquor, while wine is employed as its source in those countries where the grape is abundantly cultivated.

1899. The colour of vinegar varies according to the materials from which it has been obtained; that manufactured in England is generally artificially coloured with burnt sugar: its taste and smell are agreeably acid. Its specific gravity is liable to much variation; it seldom exceeds 1.0250. When exposed to the air it becomes mouldy and putrid, chiefly in consequence of the mucilage which it contains, and from which it may be in some measure purified by careful distillation. According to Mr. R. Phillips, (*Remarks on the London Pharmacopœia,*) when good malt vinegar of the specific gravity of 1.020 is distilled, the first eighth that passes over is of the specific gravity 0.997; the next six-eighths are of specific gravity 1.0023, and a fluid ounce decomposes 8.12 grains of precipitated carbonate of lime. The lightness of the first portion is owing to its containing alcohol, consequently, in the *Pharmacopœia* process it is ordered to be rejected. The term *distilled vinegar*, or *dilute acetic acid*, is properly applied to the second portion; it is erroneously called *acetic acid*, in the *Pharmacopœia*. The matter which remains in the still is empyreumatic, and generally contains some other vegetable acids: when the vinegar has been adulterated, which is not unfrequently the case, we sometimes find in it muriatic and sulphuric acids.

1900. Distilled vinegar is colourless, and of a flat acid taste; it consists essentially of the real acid diluted with water. To obtain *acetic* acid, or, as it has been sometimes called, *radical vinegar*, distilled vinegar may be saturated with some metallic oxide, and the acetate thus obtained, subsequently decomposed.

1901. Acetic acid is thus procured by distilling *acetate of copper*, or *crystallized verdigris*, in a glass retort heated gradually to redness: it requires re-distillation to free it from a little oxide of copper which passes over in the first instance. Acetic acid may also be obtained by distilling *acetate of soda* or *acetate of lead* with half its weight of sulphuric acid: or from a mixture of equal parts of sulphate of copper and acetate of lead; in these cases, the acid passes over at a moderate temperature.

1902. A considerable quantity of acetic acid is also now procured by the distillation of wood in the process of preparing charcoal for the manufacture of gunpowder. The liquor at first procured is usually termed *pyroligneous acid;* it is empyreumatic and impure, and several processes have been contrived to free it from tar and other matters which it contains. It may be saturated with chalk and evaporated, by which an impure acetate of lime will be obtained, and which, mixed with sulphate of soda, furnishes, by double decomposition, sulphate of lime and acetate of soda: the latter distilled with sulphuric acid affords a sufficiently pure acetic acid, which by dilution with water may be reduced to any required strength. The purification of this acid has been brought to great perfection by Dr. Bollman.

1903. Acetic acid obtained by these processes is transparent and colourless, its odour highly pungent and it blisters and excoriates when applied to the skin. Its specific gravity is 1.080. It is extremely volatile, and its vapour readily burns. It combines in all proportions with water, and when considerably diluted, resembles distilled vinegar. When highly concentrated, it crystallizes at the temperature of 40°, but liquefies when its heat is a little above that point.

1904. According to Berzelius, whose analysis of acetic acid was very carefully conducted, (THOMSON's *Annals*, Vol. iv.) its ultimate components are

Carbon	46.83
Oxygen	46.82
Hydrogen	6.35
	100.00

These numbers, reduced to definite proportionals, are

3 proportionals of hydrogen 1 × 3 = 3.
4 ———— carbon 5.7 × 4 = 22.8
3 ———— oxygen 7.5 × 3 = 22.5
48.3

Hence we see that there is no excess of oxygen in acetic acid, but that it consists of

3 proportionals of water 8.5 × 3 = 25.5
4 ———— carbon 5.7 × 4 = 22.8
48.3

The chemist above quoted has given the composition of acetate of lead, at 100 acid + 217.5 oxide of lead, and

217.5 : 100 :: 104.5 : 48.

so that the number 48 may safely be adopted as the representative of acetic acid.

1905. The acetates are all soluble in water, and mostly very soluble: many of them are deliquescent, and difficultly crystallizable; they are decomposed by sulphuric acid, and when submitted to destructive distillation, furnish a modified vinegar, which has been termed *pyroacetic acid* or *spirit:* these decompositions have been fully investigated, and the properties of the pyroacetic spirit inquired into, by Mr. Chenevix.—*Annales de Chimie,* xlix.

The following are among the most important of the acetates:

1906. *Acetate of Ammonia* is a very deliquescent, soluble salt, and extremely difficultly crystallizable. In solution, obtained by saturating distilled vinegar with carbonate of ammonia, it constitutes the *liquor ammoniæ acetatis* of the *Pharmacòpæia,* which has long been used in medicine as a diaphoretic, under the name of *spirit of Mindererus.*

1907. *Acetate of Potassa* is usually formed by saturating distilled vinegar with carbonate of potassa, and evaporating to dryness. If this salt be carefully fused, it concretes into a lamellar deliquescent mass on cooling. It is the *terra foliata tartari,* and *febrifuge salt of Sylvius* of old pharmacy. It dissolves in its own weight of water at 60°, and the solution has an acrid saline taste. It consists of one proportional of each of its components, or 45 potassa + 48 acetic acid = 93 acetate of potassa.

1908. *Acetate of Soda* forms prismatic crystals, not deliquescent, of an acrid bitterish taste, and soluble in rather less than three parts of water at 60°. It is the *terra foliata crystallisata* of old writers. It consists of 29.5 soda + 48 acetic acid.

1909. *Acetate of Lime*, is a difficultly crystallizable salt, readily soluble in water, and of a bitter saline taste; consisting of 26.5 lime + 48 acid. It is sometimes obtained by saturating the vinegar formed during the distillation of wood, and employed in the preparation of *acetate of alumina*, which is used by the calico-printers as a mordant.

1910. *Acetate of Baryta* furnishes acicular crystals of a sour and bitterish taste: in cold weather the concentrated solution congeals into a silky congeries of crystals. It requires rather more than its own weight of water at 60° for solution, and consists of 48 acid + 72.5 baryta.

1911. *Acetate of Strontia* furnishes small permanent crystals, consisting of 48 acid + 52 strontia.

1912. *Acetate of Magnesia* is uncrystallizable, and of a bitterish sweet taste. It consists of 48 acid + 18.5 magnesia.

1913. *Acetate of Manganese*, formed by dissolving the protocarbonate in acetic acid, crystallizes in rhomboidal tables, permanent, and of a reddish colour and astringent metallic taste, soluble in 3½ parts of water at 60°. They consist of 70 acid and water + 30 protoxide of manganese.—JOHN, GEHLEN'S *Journal*. iv.

1914. *Acetate of Iron*. The acetic acid combines with both oxides of iron. The *protacetate* is formed by digesting sulphuret of iron in acetic acid; it yields green prismatic crystals, of a styptic taste, and readily soluble in water; the solution becomes brown by exposure to air, and passes into *peracetate*, which is uncrystallizable, and obtained by digesting iron in acetic acid. This compound is extensively used by calico printers, who prepare it either by digesting iron in pyroligneous acid, or by mixing solution of acetate of lead with sulphate of iron, and exposing the filtered solution to air.

1915. *Acetate of Zinc* is formed either by dissolving oxide of zinc in acetic acid, or by mixing a solution of sulphate of zinc with one of acetate of lead. It crystallizes in thin shining plates of a bitter and metallic taste, very soluble, but not deliquescent. This salt is sometimes used in pharmacy, chiefly as an external application. According to Messrs. Aikin, the specific gravity of a saturated solution of acetate of zinc, made by digesting the salt in distilled vinegar, is 1055. Of this solution 900 grains contain 53 of dry, or 82.6 of crystallized acetate. One ounce by measure of the solution weighs 506 grains, and contains 29.8 grains of dry, or 46.5 grains of crystallized salt.

1916. *Acetate of Tin.* This metal is slowly acted on by acetic acid, but a *protacetate* and *peracetate of tin* may be made by mixing acetate of lead with saturated solutions of the protomuriate and permuriate of tin. These solutions have been recommended as mordants for the use of dyers. The protacetate is crystallizable. Vinegar kept in tin vessels dissolves a very minute portion of the metal; and in pewter vessels it likewise dissolves a small portion of the lead, where in contact both with the vinegar and air; hence distilled vinegar, which has been condensed in a pewter worm, affords generally traces of both metals.—VAUQUELIN, *Annales de Chimie*, xxxii.

1917. *Acetate of Copper.* By exposing copper to the fumes of vinegar, it becomes gradually incrusted with a green powder called *verdigris*, which is separable by the action of water, into an insoluble *subacetate of copper*, and a soluble *acetate.*

Acetate of copper may be obtained by digesting verdigris, or oxide of copper, in acetic acid; by evaporating this solution, it is obtained in prismatic crystals of a fine green tint. It dissolves sparingly in water and alcohol, and communicates a beautiful blue-green colour to the flame of the latter; by distillation it affords a very pure acetic acid. According to Dr. Thomson, acetate of copper, in its crystallized state, consists of

1	proportional of acid	48.
1	———— oxide of copper	67.5
8	———— water	66.
		181.5

1918. *Acetate of Lead*, is the *sugar of lead*, and *salt of Saturn* of the old chemists: it may be regarded as the most important of the acetates; it is used in pharmacy, and by dyers and calico-printers for the preparation of acetate of alumina and of iron, which are formed by mixing its solution with that of the sulphates of those metals, an insoluble sulphate of lead being at the same time produced. Acetate of lead is formed by digesting the carbonate in distilled vinegar, or in the acetic acid obtained by the destructive distillation of wood; it usually occurs in masses composed of acicular crystals; but by careful crystallization it may be obtained in quadrangular prisms. Its taste is sweet and astringent, and it is soluble in about four parts of water, at 60°. It is sometimes improperly termed a *superacetate*, but the salt is neutral, though when dissolved in water containing the smallest portion of carbonic acid, a white insoluble compound of lead falls, and a little acetic acid being liberated, the solution is rendered sour.

Carbonic acid passed through a solution of acetate of lead, precipitates, as I am informed by Mr. James South, exactly half the quantity of the oxide which the salt contains; hence a *binacetate* is probably formed, which however does not afford crystals.

According to the experiments of Berzelius, acetate of lead consists of

Acetic acid	26.97
Protoxide of lead	58.71
Water	14.32
	100

hence the dry acetate is composed of

1 proportional of acetic acid........	48
1 ———————— yellow oxide of lead	104.5

When acetate of lead is submitted to destructive distillation it furnishes a considerable quantity of a peculiar fluid, smelling and burning like alcohol.—PROUST, *Journal de Physique*, Tom. lvi.

1919. When 100 parts of sugar of lead are boiled in water, with about 150 of yellow oxide, or of finely powdered litharge, a salt is obtained which crystallizes in plates, and is less sweet and soluble than the acetate; it has been termed *subacetate of lead*, and consists, according to Berzelius, of 1 proportional of acid = 48 + 3 proportionals of oxide of lead, 313.5. This compound has long been used in pharmacy, under the name of *Goulard's extract of lead*. It is very rapidly precipitated by carbonic acid, of which it is a most delicate test; it also has a strong attraction for vegetable colouring matter, upon which principle I employed it in my analysis of wines.—*Phil. Trans.*, 1813.

1920. *Acetate of Antimony*, formed by digesting the protoxide in acetic acid, was once employed as an emetic.

1921. *Acetate of Bismuth* may be formed by adding nitrate of bismuth to a concentrated solution of acetate of potassa; a precipitate falls, which redissolves on the application of heat, and afterwards affords scaly crystals. The addition of acetic acid to nitrate of bismuth prevents its precipitation when diluted.—MORVEAU, *Encycl. Méthod. Chimie*, i. 10.

1922. *Acetate of Cobalt* may be obtained by digesting oxide of cobalt in acetic acid; it is uncrystallizable, and furnishes a sympathetic ink, colourless when cold, but blue when heated.

1923. *Acetate of Uranium* forms four-sided prismatic crystals of a yellow colour.

1924. *Acetate of Titanium*, not examined.

1925. *Acetate of Cerium*. Recently precipitated oxide of cerium readily dissolves in acetic acid, and yields small crystals on evaporation, of a sweetish taste, permanent, and readily soluble in water.—HISINGER and BERZELIUS, GEHLEN'S *Journal*, ii. 414.

1926. *Acetate of Nickel* forms green rhomboidal crystals.

1927. *Acetate of Mercury*. *Protacetate of Mer-*

cury is most readily formed by mixing a solution of protonitrate of mercury with acetate of potassa. For this purpose dissolve three ounces of mercury in about four ounces and a half of cold nitric acid, and mix this solution with three ounces of acetate of potassa previously dissolved in eight pints of boiling water, and set the whole aside to crystallize, which takes place as the liquor cools, and the acetate of mercury then separates in the form of micaceous crystalline plates, which are to be washed in cold water, and dried on blotting paper. (*Edinburgh Pharmacopœia.*) In preparing this salt, the quantity of water for dissolving the acetate need not be so large as above directed, one pint being sufficient, but it is necessary to pour the mercurial solution into the acetate. This salt has an acrid taste, and is very difficultly soluble in water, requiring, according to Braconnot, (*Annales de Chimie,* lxxxvi. 92.) 600 parts of water. It is insoluble in alcohol. It was once used in medicine.

1928. *Peracetate of Mercury* is formed by digesting the peroxide in acetic acid; it does not crystallize, and affords on evaporation a deliquescent yellow mass, which is decomposed by water into a *superperacetate,* which remains dissolved; and an insoluble *subperacetate.*—Proust, *Journal de Phys.,* lvi.

1929. *Acetate of Silver* is obtained by boiling the acid on oxide of silver, or by mixing solutions of acetate of potassa and nitrate of silver; it forms acicular crystals of an acrid metallic taste.

1930. *Acetate of Alumina.* This salt is extensively employed by calico-printers as a mordant or basis for fixing colours; they produce it by mixing solutions of alum and acetate of lead: about three pounds of alum are dissolved in eight gallons of water and a pound and a half of sugar of lead stirred into it; a copious formation of sulphate of lead ensues, which is allowed to subside, and the clean liquor holding acetate of alumina and a portion of undecomposed alum in solution, is then drawn off, a portion of pearlash and chalk being added to it previous to use, in order to saturate any excess of acid.

Acetate of alumina, formed by digesting recently precipitated alumina in acetic acid, may be procured in deliquescent acicular crystals of an astringent taste, and containing, according to Richter, 73.81 acid + 26.19 alumina: hence it is probably a *binacetate*.

CHAPTER IX.

Of Animal Substances.

1931. THE different sections of this chapter will contain an account of the ultimate and proximate principles of the substances belonging to the animal creation, of the different methods of analysis by which these principles are obtained, and of such of the animal functions as are concerned in their production, where these are susceptible of chemical elucidation.

SECTION I. *Of the ultimate Principles of Animal Matter, and of the Products of its destructive Distillation.*

1932. THE proximate principles of the animal creation consist, like those of vegetables, of a few elementary substances, which by combination in various proportions, give rise to their numerous varieties. Carbon, hydrogen, oxygen, and nitrogen, are the principal ultimate elements of animal matter; and phosphorus and sulphur are also often contained in it. The presence of nitrogen constitutes the most striking peculiarity of animal, compared with vegetable bodies; but as some vegetables contain nitrogen, so there are also certain animal principles, into the composition of which it does not enter.

1933. The presence of nitrogen stamps a peculiarity upon the products obtained by the destructive distillation of animal matter, and which are characterized by the presence of ammonia, formed by the union of the hydrogen with the nitrogen. It is sometimes so abundantly generated as to be the leading product; thus, when horn, hoofs, or bones, are distilled *per se*, a quantity of solid carbonate of ammonia, and of the same substance combined with empyreumatic oil, and dissolved in water, are obtained; hence the pharmaceutical preparations called *spirit* and *salt of hartshorn*, and Dippel's *animal oil*. Occasionally the acetic, benzoic, and some other acids are formed by the operation of heat on animal bodies, and these are found united to the ammonia; cyanogen and hydrocyanic acid also frequently occur.

If the gas evolved during the decomposition of animal bodies be examined, it is generally inflammable, and consists of carburetted hydrogen, often with a little sulphuretted and phosphuretted hydrogen; carbonic oxide, carbonic acid, and nitrogen, are also sometimes detected in it.

The coal remaining in the retort is commonly very difficult of incineration, a circumstance depending upon the common salt and phosphate of lime, which it usually contains, forming a glaze upon its surface which defends the carbon from the action of the air. Animal charcoal is also found to be more effectual in destroying colour and smell, than that obtained from vegetables. (387.)

1934. By the term *putrefaction* we mean the changes which dead animal matter undergoes, and by which it is slowly resolved into new products. These changes require a due temperature, and the presence of moisture; for below the freezing point of water, or when perfectly dry, it undergoes no alteration.

During putrefaction the parts become soft and flabby, they change in colour, exhale a nauseous and disgusting odour, diminish considerably in weight, and afford several new products, some of which escape in a gaseous form, others run off in a liquid state, and others are contained in the fatty, or earthy residuum.

The presence of air, though not necessary to putrefaction, materially accelerates it, and those gases which contain no oxygen, are very efficient in checking or altogether preventing the process. Carbonic acid also remarkably retards putrefaction; and if boiled meat be carefully confined in vessels containing that gas, it remains for a very long time unchanged, as seen in M. Appert's method of preserving meat.

There are several substances which, by forming new combinations with animal matter, retard or prevent putrefaction, such as many of the saline and metallic compounds; sugar, alcohol, volatile oils, acetic acid, and many other vegetable substances also stand in the list of anti-putrefactives, though their mode of operating is by no means understood.

1935. The effluvia which arise from putrescent substances, and more especially those generated in certain putrid disorders, have a tendency to create peculiar diseases, or to give the living body a tendency to produce poisons analogous to themselves. An atmosphere thus tainted by infectious matter, may be rendered harmless by fumigation with the volatile acids, more especially the nitrous and the muriatic; chlorine is also very effectual: the vapour of vinegar, though sometimes useful in covering a bad smell, is not to be relied on. It appears evident that the acid and chlorine act chemically upon the pernicious matter, and resolve it into innocuous principles.

1936. When muscular flesh is immersed in a stream of running water, it is partially converted into a substance having many of the properties of fat combined with a portion of ammonia. The same changes have been observed where large masses of putrefying animal matter have been heaped together, or where water has had occasional access to it. Nitrate of ammonia is also sometimes formed under the same circumstances.

1937. Instead of considering the proximate principles of animals under separate sections, as has been done in regard to vegetable bodies, I shall make them known under the heads of those substances in which they occur, the principal of which are the following:

1. Blood. Albumen, Colouring Matter.
2. Milk. Sugar of Milk.
3. Bile. Resin of Bile.
4. Lymph. Mucus. Synovia, Pus, *&c.*
5 Urine. Urea. Urinary Calculi.
6. Skin. Membrane.
7. Muscle. Ligament. Horn. Hair.
8. Fat. Spermaceti, *&c.*
9. Cerebral substance.
10. Shell and Bone.

SECTION II. *Of the Blood.*

1938. IN the higher orders of animals the blood is of a red colour, florid in the arteries, and dingy in the veins. The specific gravity of human blood is liable to some variation. I have found it as low as 1.050 and as high as 1.070, but am unable to refer to any circumstances which might be considered as the cause of this difference.

When blood is drawn from its vessels in the living animal, it soon concretes into a jelly-like mass, which afterwards gradually separates into a fluid *serum*, of a pale straw colour, and a coagulated *crassamentum*, or *cruor*, which is red. The cause of this coagulation is quite unknown.

1939. The specific gravity of the serum of the blood, is upon an average 1.030. It reddens the yellow of tumeric, and changes the blue of violets to green, a property derived from a portion of soda. At a temperature of 160°, it becomes a firm yellowish white coagulum, resembling in appearance and properties the coagulated white of egg, and, as the principle to which this property is owing is the same in both substances, it has been called *albumen*. Alcohol, and many of the acids, also occasion the coagulation of the serum of blood.

100 parts of human serum contain between eight and nine parts of albumen, rather less than one part of carbonate of soda, and about the same quantity of

common salt, the remaining 90 parts being water. These at least are the proportions which my own experiments lead me to believe correct; but the analysis is involved in so much difficulty that the results can only be considered as approximating to the truth; indeed it is probable that the composition of the serum is liable to much variation.

Dr. Marcet and Berzelius have each given an analysis of the serum of human blood; the following are their results. (*Medico-Chirurgical Transactions*, Vol. ii. *Annals of Philosophy*, Vol. ii.):

MARCET.

Water	900.
Albumen	86.8
Muriates of potassa and soda	6.6
Muco-extractive matter	4.0
Carbonate of soda	1.65
Sulphate of potassa	0.35
Earthy phosphates	0.60
	1000.00

BERZELIUS.

Water	905.0
Albumen	80.0
Muriates of potassa and soda	6.0
Lactate of soda, with animal matter	4.0
Soda and phosphate of soda with ditto	4.1
Loss	0.9
	1000.0

1940. *Albumen*, which constitutes a leading ingredient in the serum, and which we shall presently find also in the cruor, is a very important animal principle, and is found in the greater number of animal fluids and solids.

Liquid Albumen is soluble in water, and always contains a notable portion of soda, indicated by its action on vegetable colours. It is coagulated by heat, acids, and alcohol, unless it be considerably diluted with water, in which case a portion separates in the form of white flakes after some hours' standing. Solution of corrosive sublimate, added to albumen very much diluted, produces a cloudiness, and hence it is a useful test of albumen. (BOSTOCK, NICHOLSON'S *Journal*, xiv.) It is also instantly coagulated by Voltaic electricity; and if two platinum wires connected with a small battery be immersed into a diluted albumen, it will cause a very rapid coagulation at the negative pole, and scarcely any effect at the positive pole. This circumstance induced me to attribute the coagulation to the removal of the alcali, by alcohol, and by acids; but how heat operates is not very obvious, unless we be allowed to consider it as effecting a kind of decomposition of the liquid albumen. We might thus consider liquid albumen as a compound of albumen and soda dissolved in water: the effect of heat would then be to transfer the soda to the water, and thus occasion a coagulation; and a solution of soda is always found oozing from coagulated serum, and has sometimes been called *serosity;* in time it re-àcts upon the coagulum, and dissolves a portion of it.

1941. When albumen is dried in a moderate heat, it shrinks and becomes brown and semi-transparent, resembling horn in appearance and properties. In this state it scarcely dissolves in boiling water, though it gradually softens; it is not prone to decomposition;

it dissolves in the alcalis, a portion of ammonia being evolved and a saponaceous compound formed. Dilute nitric acid converts it into a substance having the properties of gelatine. (HATCHETT, *Phil. Trans.*, 1800.)

By destructive distillation albumen furnishes a variety of products characterized by the presence of a large proportion of ammonia. According to Gay-Lussac and Thenard, (*Recherches Physico-chymiques*) its ultimate constituents are

Carbon	52.883
Oxygen	23.872
Hydrogen	7.540
Nitrogen	15.705
	100.000

1942. When the coagulum of the blood is carefully washed under a small stream of water, the colouring matter is gradually dissolved, and washed out of it, and a white fibrous substance remains, which has been termed *fibrina* or *coagulable lymph,* but of which the chemical properties are those of albumen.

It sometimes happens, when the blood is long in coagulating, as in certain inflammatory diseases, that a portion of this albumen is left without the colouring matter, forming what has been called the *buffy coat of blood ;* in this case it is so tough as to admit of being removed from the coloured portion, and when dried, shrinks up, and appears exactly like horn.

Although the cause of the spontaneous coagulation of blood be unknown, the process consists in a portion of the albumen separating in a solid form along with the colouring matter, while another portion remains dissolved in the serum; this effect is somewhat analogous to the crystallization of a saline solution, in which one portion of the salt separates, while another remains dissolved.

1943. The colour of the blood has generally been referred to small globules of a red colour, which by the aid of the microscope may be discerned in it; and it was supposed that these globules are soluble in water. But it has been shown by Dr. Young, that this is not the case, and that the effect of water is to dissolve the colouring matter only, leaving the globule perfectly colourless; in this state the globular particles have the properties of albumen. The diameter of the globules in human blood varies from $\frac{1}{6000}$ to $\frac{1}{4000}$ of an inch.—*Remarks on Blood and Pus, in* Dr. Young's *Medical Literature.*

The colouring matter of the blood can scarcely be obtained free from other substances. By stirring it during coagulation, a considerable portion is diffused through the serum from which it afterwards subsides. Vauquelin advises the digestion of the coagulum, drained of serum, in dilute sulphuric acid, at a temperature of 160°. The liquid, filtered while hot, is to be evaporated to half its bulk, and nearly saturated with ammonia; the colouring matter falls, and is to be washed and dried. (*Annales de Chimie et Physique,* Tom. i.) We must not, however, trust animal principles to these complex operations; and there can, I think, be little doubt that the colouring principle has undergone some change in M. Vauquelin's process.

The chemical properties of the colouring matter of the blood show that it is a peculiar animal principle.

It is soluble in cold water, and the solution, when boiled, deposits a brown sediment of altered colouring matter. Muriatic, dilute sulphuric, and several of the vegetable acids, and the caustic and carbonated alcalis, readily dissolve the colouring matter, and form solutions of different tints of red, and of a peculiar greenish hue when viewed by transmitted light. Nitric acid instantly renders these solutions brown, and decomposes the red principle. These experiments, of which I have given a detailed account in the *Philosophical Transactions* for 1812, led me to regard the colouring matter of the blood as a distinct proximate principle of animal matter, perfectly independent of the presence of iron, to which its peculiarities were at one time referred by MM. Fourcroy and Vauquelin; and the latter of these celebrated chemists has more lately verified my conclusions in the above-quoted memoir. Berzelius, whose labours in animal chemistry are so extended and well known, has, however, obtained different results; he finds the crassamentum of the blood to consist of

Colouring matter	64
Fibrin and albumen	36
	100

The colouring matter, when incinerated, affords a residue, consisting of

Oxide of iron	50.0
Subphosphate of iron	7.5
Phosphate of lime with magnesia	6.0
Lime	20.0
Carbonic acid and loss	16.5
	100.0

The iron appears to be regarded by Berzelius as contributing to the red colour of the blood, (THOMSON's *System*, Vol. iv., p. 501.) a conclusion which my own experiments, detailed in the paper already quoted, by no means warrant, and which is also at variance with the opinion of M. Vauquelin.'

1944. Besides the principles now enumerated, and which may be considered as essential to the blood, it often contains carbonic acid, which escapes when the blood is gently heated, or placed under the exhausted receiver of the air-pump.

Experiments on the blood, in different diseases, have thrown no light whatever on their nature, nor have any material differences been found in the blood of the same animal at different periods, or in that of different animals of the same class.

SECTION III. *Milk.*

1945. THE chemical properties of this secretion differ somewhat in different animals. The milk of the cow has been most attentively examined, and it has the following properties:

It is nearly opaque; white, or slightly yellow; of an agreeable sweetish taste, and a peculiar smell. Its specific gravity varies from 1018 to 1020. It boils at a temperature a little above that of water, and freezes at 32°. When allowed to remain a few hours at rest, a thick unctuous liquid collects upon its surface, called *cream;* the colour of the remaining milk becomes bluish white, and when heated to about 100° with a little *rennet,* it readily separates into a *coagulum* or *curd,* and a *serum* or *whey.* In this way the three principal constituents of milk are separable from each other.

1946. By the process of churning, cream is separated into *butter* and *butter-milk,* the latter being the whey united to a portion of curd. According to Berzelius, 100 parts of cream, of the specific gravity of 1024, consists of

Butter	4.5
Curd	3.5
Whey	92.0
	100.0

Butter may be considered as an animal oil, containing a small portion of curd and whey. It liquefies at about 98°, and by this process the impurities are separated, and it remains a longer time without becoming rancid.

1947. The *curd* of milk has the leading properties of coagulated albumen, and, like that principle, is coagulable by alcohol and acids, and is also similarly affected by Voltaic electricity; heat slowly produces the same effect, and by boiling milk, the albumen separates in successive films.

1948. Curd, in combination with various proportions of butter, constitutes the varieties of *cheese;* that containing the largest quantity of oil becomes semi-fluid when heated; it is prone to decomposition, and a large quantity of ammonia is then formed in it; whereas bad cheese, which consists of little else than curd or albumen, shrinks and dries when heated, curling up like a piece of horn.

1949. *Whey* is a transparent fluid of a pale yellow colour and a sweetish flavour; by evaporation it affords a minute quantity of saline matter, and a considerable portion of sugar of milk.

1950. *Sugar of Milk* may be obtained in white rhomboidal crystals, of a sweet taste, and soluble in seven parts of water at 60°, but insoluble in alcohol. When exposed to heat, it affords nearly the same products as common sugar. It consists, according to Berzelius, when deprived of water, of

Carbon..............	45.267
Oxygen..............	48.348
Hydrogen............	6.385
	100.000

1951. When sugar of milk is treated with nitric acid, it affords a peculiar acid, similar to that abovementioned, as obtained from gum (1534). To procure this acid, one part of powdered gum arabic may be digested in two of nitric acid, in a moderate heat; as soon as effervescence commences, set the flask in a cool place, and a quantity of white powder subsides, which is to be collected upon a filter, digested in dilute nitric acid to separate oxalate of lime, and subsequently purified by boiling water, which deposits the *mucic* or *saclactic acid* on cooling. If sugar of milk be used instead of gum, it is obtained pure by the first operation. This acid is not crystallizable, and is sparingly soluble in water, requiring 60 parts at 212°, and is deposited as the solution cools, in the form of a white gritty powder, of a slightly acid taste. It combines with the metallic oxides, and forms a class of salts called *saccholates*. It consists, according to Berzelius, (*Annals of Philosophy*, Vol. v.) of

Carbon	33.430
Oxygen	61.465
Hydrogen	5.105
	100.000

1952. The *saccholates*, or *saclactates*, have scarcely been examined. With ammonia, potassa, and soda, this acid forms crystallizable compounds, more soluble than the acid. The saclactates of lime, baryta, and strontia, are insoluble, as are those of silver, mercury, and lead.

1953. When milk or whey are exposed to a temperature between 60° and 80°, they undergo a spontaneous change, attended by the production of an acid, which was originally examined by Scheele, and has been termed *lactic acid*. Fourcroy and Vauquelin have shown reason to suspect its peculiar nature, and were led to regard it as identical with the acetic acid. Berzelius has more recently revived the opinion of Scheele, but I am induced from my own experiments to believe, that if it be not the acetic acid originally, it becomes so by combination with a base, and subsequent separation by sulphuric acid.

1954. In some cases whey may be made to undergo vinous fermentation; and the Tartars, it is said, prepare a kind of wine from the whey of mares' milk, which they call *Koumiss*.—*Edinburgh Phil. Trans*.,. Vol. ii.

SECTION IV. *Bile.*

1955. THIS secretion is formed in the liver, from venous blood. It is an unctuous liquid, of a yellowish green colour, and its specific gravity is between 1020 and 1030. Its taste is intensely bitter, and it readily putrefies, exhaling a most nauseous odour.

1956. When the bile of the ox is distilled, it affords about 90 *per cent.* of insipid water; the residuum is brown, bitter, and may be re-dissolved in water; it affords traces of uncombined alcali, which appears to be soda. The acids render bile turbid, and separate from it a substance which possesses many of the properties of albumen. It is likewise coagulated by alcohol, and upon filtering off the clear liquor and evaporating it, an inflammable fusible substance is obtained, of an intensely bitter flavour, combined with a portion of soda and common salt: this has been termed the *resin of bile,* and appears to be the principle which confers upon it its chief peculiarities. We should, therefore, conclude, as the result of these observations, that bile consists of water, albumen, soda, a bitter resin, and some minute portions of saline matter.

1957. Thenard separated from bile a peculiar substance, which he has termed *picromel;* but the process by which he obtained it is so complex, that I think it doubtful whether it be a product or an educt. The same chemist has given the following table of the ingredients of ox-bile, but as this secretion is liable to considerable variation in appearance and specific gravity, it is probable that little reliance can be placed in the accuracy of the numbers (*Traité de Chimie,* Tom. iii., p. 556.):

Water	700
Resin	15
Picromel	69
Yellow matter	4
Soda	4
Phosphate of soda	2
Muriates of soda and potassa	3.5
Sulphate of soda	0.8
Phosphate of lime and of magnesia	1.2
Oxide of iron	a trace
	1000.

1958. *Biliary Calculi* are of two kinds; those which most commonly occur, are soft, fusible, of a crystalline texture, and inflammable. They have generally been considered as closely resembling spermaceti; they are soluble in boiling alcohol, in ether, and difficultly in oil of turpentine. Chevreul, having remarked some peculiarities in this substance, is induced to regard it as a peculiar animal principle, and distinguishes it by the name of *cholesterine.*

1959. Cholesterine is fusible at 280°, and on cooling concretes into a crystalline mass; rapidly heated to about 400° it evaporates in dense smoke; it is insoluble in water, and nearly so in cold alcohol; boiling alcohol dissolves about $\frac{1}{20}$ its weight. It is soluble in nitric acid; but not convertible into soap by the alcalis.

1960. The other kind of biliary calculus resembles inspissated bile in appearance, but differs from it in being insoluble in alcohol and water. It is often mixed with variable proportions of the former, constituting biliary calculi of intermediate characters.

1961. The gall-stone of the ox is nearly insoluble in water and alcohol, and appears to consist chiefly of the yellow matter of bile; painters sometimes use it as a yellow pigment.

SECTION V. *Lymph, Mucus, Pus, &c.*

1962. THE liquid which lubricates the different cavities of the body, which is contained in the lymphatics, and which occasionally forms the chief contents of the thoracic duct, has been termed *lymph*. It is colourless, transparent, miscible in all proportions with water, does not affect vegetable blues, is not coagulated by acids or alcohol, but only rendered slightly turbid by the latter. It has the characters of a very weak solution of albumen.

The fluid which collects in cases of dropsy and in vesications, is of a similar nature, but the proportion of albumen is liable to variation, and hence it is differently influenced by tests; when very rapidly thrown out from inflamed surfaces, it sometimes furnishes a coagulum, apparently as abundant as that of the serum of the blood.

1963. The term *mucus* has sometimes been applied to these fluids, when they have undergone a certain degree of inspissation; at other times, it has been used to designate a very alcaline albuminous fluid. Dr. Bostock has pointed out some circumstances in which mucus differs from liquid albumen, and has proposed subacetate of lead as a test for its presence. (Nicholson's *Journal,* Vol. xi.) But that salt is so easily decomposed by many vegetable and animal substances, as to render it of doubtful efficacy for this purpose.

1964. *Saliva* consists, according to Dr. Bostock, (Nicholson's *Journal,* Vol. xiv.) of

Water	80
Coagulated albumen	8
Mucus	11
Saline substances	1
	100

I found that it was copiously coagulable by the action of Voltaic electricity, and was hence induced to consider the mucus as a peculiar albuminous combination, not coagulable by the usual means.—*Phil. Trans.,* 1809.

1965. The *Pancreatic juice* has not been minutely examined, but from the experiments of Dr. Fordyce, it would appear to differ little from saliva.

1966. *Tears* contain a small portion of albumen combined with soda, muriate of soda, and water. There are also small portions of other salts.

1967. *The humours of the Eye.* The *aqueous humour* is composed of water holding a minute quantity of albumen and saline matter in solution; the *crystalline lens* also contains more than half its weight of water, the remainder being an albuminous substance with traces of muriates.

1968. *Synovia* is the fluid which lubricates the surfaces of joints. It contains, according to Mr. Hatchett, (*Phil. Trans.*, 1799.) a small portion of phosphate of lime, and of phosphate of soda and ammonia; the animal principle appeared to be albumen.

1969. *Pus* is a term applied to a variety of secretions from abcesses and ulcerated surfaces. When it indicates a healing sore, it has been called *healthy pus*, and has the following properties. It has the consistency of cream, a yellowish colour, and exhibits, under the microscope, the appearance of globules diffused through a fluid. (HOME, *On Ulcers*, 2 Edit., p. 13.) Its specific gravity is about 1.030. It does not affect vegetable colours till it has been some time exposed to air, when it becomes slightly sour; it does not easily mix with water, alcohol, or dilute acids.—See Dr. PEARSON'S *Experiments on Pus*, NICHOLSON'S *Journal*, XXX.

SECTION VI. *Urine, Urinary Calculi, &c.*

1970. THIS secretion presents, perhaps, greater difficulties to the analytical chemist, than any other animal product; it is extremely complex, and subject to constant change in the proportions of its components, and in disease several new substances make their appearance.

The chemical history of the urine is of the utmost importance to the medical practitioner; it teaches the nature of the substances which occasionally predominate, so as to constitute *gravel* and *calculi;* and shows the means of influencing and modifying its composition.

The general characters of the urine are too well known to need description. Its specific gravity is of course liable to much variation even in the healthy state, fluctuating between 1005 and 1040. The average is about 1020.

1971. The substances that are always found in urine are, according to my own experiments, the following:

1. Water.
2. Carbonic acid.
3. Phosphoric acid.
4. Uric acid.
5. Phosphate of lime.
6. Phosphate of ammonia.
7. Phosphate of soda.
8. Phosphate of magnesia.
9. Common salt.
10. Sulphate of soda.
11. Albumen.
12. Urea.

1972. The existence of free acid in recently voided urine is easily demonstrated by its property of reddening vegetable blues, and it performs the important office of retaining some of the difficultly soluble salts in permanent solution; so that whenever this natural acidity is diminished, the urine has a tendency to deposit the earthy phosphates.

1973. The presence of *carbonic acid* may be shown by placing urine under the receiver of the air-pump; during exhaustion it escapes, sometimes copiously, but at other times in minute quantities only.

1974. The free *phosphoric acid* may be shown by the addition of carbonate of lime, a portion of which is converted into phosphate of lime.

1975. *Uric acid* is one of the peculiar characteristics of the urine; its presence may be shown by evaporating urine to half its bulk, which produces a precipitate consisting of phosphate of lime and uric acid; the former may be dissolved by dilute muriatic acid, which leaves the latter in the form of a reddish powder. This acid has been very ably examined by Dr. Henry, who made it the subject of a thesis published in 1807: Dr. Prout has also given much valuable information in relation to it.

Uric acid, called sometimes lithic acid, as constituting the principal ingredient in certain urinary calculi, may be abundantly obtained by digesting such calculi (1990) in caustic potassa, filtering the solution, and adding excess of muriatic acid, which causes a precipitate of uric acid, which is to be washed with warm water, and dried.

Uric acid thus obtained, is a grey powder, of scarcely any taste, and requiring, according to Dr. Henry, 1720 parts of water at 60°, and 1150 parts at 212° for solution. It reddens infusion of litmus, and readily dissolves in caustic potassa, and soda; it is sparingly soluble in ammonia, and insoluble in the alcaline carbonates.

According to Dr. Prout, uric acid requires at least

10000 parts of water at 60° for its solution, but urate of ammonia requires only about 480 times its weight at the same temperature, and affords a precipitate of uric acid, on the addition of any other acid; for these, among other reasons, Dr. Prout regards urate of ammonia, and not pure uric acid, as existing in urine.

1976. Uric acid dissolves in nitric acid, and upon evaporation a residuum of a fine red tint is obtained, which is peculiar to this combination, and which Dr. Prout has lately shown to possess distinct acid properties; he has called it *purpuric acid.—Phil. Trans.* 1818.

1977. When uric acid is submitted to destructive distillation, it affords carbonate of ammonia, and a peculiar compound, which sublimes in crystals, and which, according to Dr. Henry, consists of a peculiar acid united to ammonia; a quantity of charcoal remains in the retort. Its ultimate constituents, according to Dr. Prout, are

1	proportional of	nitrogen	——	13
2	,,	carbon	5.7 × 2 =	11.4
1	,,	oxygen	——	7.5
1	,,	hydrogen	——	1
				32.9

1978. The *urates* have principally been examined by Dr. Henry, and an account of many of them is given in his *Thesis* above quoted.

1979. *Phosphate of Lime* may be precipitated from urine by the addition of ammonia; its relative quantity is liable to much fluctuation; sometimes it becomes so great as to be deposited as the urine cools, constituting what has been termed *white sand.*

1980. The *Phosphates of Ammonia*, of *Soda*, and of *Magnesia*, and *common Salt*, constitute the principal crystallizable salts contained in the urine; the first of these is probably in great part produced during evaporation, for the saline mass obtained by inspissating urine is no longer acid; the carbonic having escaped, and the phosphoric being saturated by ammonia. The *microcosmic salt*, or *fusible salt of urine*, of the old chemists, is chiefly phosphate of ammonia with a little phosphate of soda, or perhaps a triple *ammonia-phosphate of soda* (598).

1981. The *Ammoniaco-magnesian Phosphate* (692) is a common, and almost constant ingredient in the urine. It forms a part of the white sand voided in certain calculous affections, and is sometimes formed in a film upon the surface of the urine, having been held in solution by carbonic acid, and being deposited as that gas escapes.

1982. The existence of *sulphuric acid*, probably combined with *soda*, and perhaps also with *potassa*, may be detected in urine by the addition of nitrate of baryta, which occasions a precipitate of sulphate of baryta.

As urine blackens silver, it has been said to contain *sulphur*; but this is not the case with recent urine, and when it becomes slightly putrid it evolves a little sulphuretted hydrogen.

1983. The existence of *albuminous matter* in urine is sometimes easily demonstrated; at others, the secretion seems not to contain it. It has been said, by Mr. Cruikshank, that the urine in some dropsical cases contains so much albumen as to be coagulable by heat, (*Phil. Mag.* Vol. ii.) but if that ever be the case, the secretion could hardly be called urine. It seems questionable whether the albumen of urine should not sometimes be regarded as derived from the mucous secretion of the bladder. Dr. Prout, in his *Inquiry into the Nature and Treatment of Gravel*, &c., has described some cases of albuminous urine, and has adverted to its method of cure.

1984. *Urea* is the principle which confers upon urine its chief peculiarities. It may be obtained by slowly evaporating urine to the consistency of syrup; on cooling it concretes into a saline mass, which, by digestion in alcohol, furnishes urea. By carefully distilling off the alcohol, the urea remains in the form of a brown crystallized mass, which, by purification, furnishes colourless prismatic crystals.

Other processes have been given for obtaining urea, which are, I think, objectionable, on account of their complexity; indeed it is doubtful whether, by the action of heat and alcohol, as above described, it is not considerably altered.

Urea is very soluble; water, at 60°, takes up about its own weight, and boiling water appears to dissolve it in any quantity, and without alteration: boiling alcohol takes up its own weight, and on cooling the urea separates in crystals. Sulphuric ether scarcely dissolves an appretiable portion. Nitric acid produces a crystalline precipitate in the aqueous solution of urea, consisting of the two substances, according to Dr. Prout, in the following proportions:

Nitric acid	47.37
Urea	52.63
	100.00

A very similar compound may also be produced with oxalic acid.

The fixed alcalis decompose urea, and occasion the evolution of ammonia and some other products. It is to this substance that the copious production of volatile alcali, during the destructive distillation of urine, is referable; and the ammonia which is found in combination with the acids, in putrid urine, is derived from the same source.

Urea combines with most of the metallic oxides; with oxide of silver the compound is grey, and it decomposes with detonation, when heated.

According to Dr. Prout's analysis (Henry's *Elements*, Vol. ii. p. 327,) urea consists of

Oxygen....	26.66	=	1	proportional	7.5
Nitrogen ..	46.66	=	1	„	13.0
Carbon	19.99	=	1	„	5.7
Hydrogen ..	6.66	=	2	„	2.0
					28.2

In some diseased states of the urine there is a morbid excess of urea, which may be detected by putting a little of the urine into a watch-glass, and carefully adding an equal quantity of nitric acid, in such a manner that the acid shall subside to the lower part of the glass; if spontaneous crystallization take place, it indicates excess of urea.—Prout *on Gravel*, &c., p. 10.

1985. Such are the properties of the principal ingredients in human urine, to which several others have been added by different chemists; but as their existence is only occasional, and often, I think, doubtful, I have hesitated to give them a place among the regular constituents of healthy urine. I now subjoin Berzelius' statement of the average composition of human urine.—THOMSON'S *Annals*, Vol. ii. 423.

Water	933.00
Urea	30.10
Sulphate of potassa	3.71
Sulphate of soda	3.16
Phosphate of soda	2.94
Muriate of soda	4.45
Phosphate of ammonia	1.65
Muriate of ammonia	1.50
Free lactic acid Lactate of ammonia Animal matter soluble in alcohol Urea not separable from the preceding	17.14
Earthy phosphates, with a trace of fluate of lime	1.00
Uric acid	1.00
Mucus of the bladder	0.32
Silica	0.03
	1000.00

1986. The urine suffers some very remarkable changes in certain diseases, which have been but superficially inquired into by chemists. In cases of injury of the spine, affecting the nerves that supply the kidneys, the urine is always turbid, and often alcaline; and there is a considerable tendency in these cases to form calculi.

In the disease called *diabetes*, the urine is not only secreted in excess, but often contains a substance of a sweet taste, having the properties of sugar, and its specific gravity is considerably above the healthy standard

(Henry *on Diabetic Urine. Medico-Chirurgical Trans.* Vol. ii. p. 118.) The following Table, constructed by Dr. Henry, shows the quantity of solid extract in a wine pint of urine, of different specific gravities, from 1020 to 1050. In the experiments which furnished the data of this table, the urine was evaporated by a steam heat till it ceased to lose weight, and left an extract, which became solid on cooling.—Prout *on Gravel*, p. 62.

Sp. gr. compared with 1000 pts. of water at 60°.	Quantity of solid extract in a wine pint.	Quantity of solid extract in a Wine Pint, in			
	grs.	oz.	dr.	scr.	grs.
1020	382.4	0	6	1	2
1021	401.6	0	6	2	1
1022	420.8	0	7	0	0
1023	440.0	0	7	1	0
1024	459.2	0	7	1	19
1025	478.4	0	7	2	18
1026	497.6	1	0	0	17
1027	516.8	1	0	1	16
1028	536.0	1	0	2	16
1029	555.2	1	1	0	15
1030	574.4	1	1	1	14
1031	593.6	1	1	2	13
1032	612.8	1	2	0	12
1033	632.0	1	2	1	12
1034	651.2	1	2	2	11
1035	670.4	1	3	0	10
1036	689.6	1	3	1	9
1037	708.8	1	3	2	8
1038	728.0	1	4	0	8
1039	747.2	1	4	1	7
1040	766.4	1	4	2	6
1041	785.6	1	5	0	5
1042	804.8	1	5	1	4
1043	824.0	1	5	2	3
1044	843.2	1	6	0	3
1045	862.4	1	6	1	2
1046	881.6	1	6	2	1
1047	900.8	1	7	0	0
1048	920.0	1	7	1	0
1049	939.2	1	7	1	19
1050	958.4	1	7	2	18

1987. The urine of graminivorous animals differs considerably from that of the human subject. Carbonates, muriates, and phosphates, are the leading ingredients; it also contains urea, but not uric acid; potassa is usually the predominating alcali. In the *Phil. Trans.* for 1808, I have given an account of the composition of several species of urine, and in that of the camel I detected a small portion of uric acid: but as the animal was diseased, its presence was probably accidental, more especially as it has not been found by other chemists.

In the urine of the snake, and of most birds that feed upon fish and animal matter, uric acid is the leading ingredient. It is also abundant in the excrement of the parrot, and of other birds who feed upon vegetables only.—J. Davy, *Phil. Trans.* 1821.

1988. It frequently happens, from a variety of causes, that certain ingredients of human urine are secreted in excess, and deposited in a solid form, constituting *sand*, or *gravel* and *calculi*.

Sand is either *white* or *red;* the former consists of phosphate of lime, and ammoniaco-magnesian phosphate, either separate or mixed, and the latter is chiefly uric acid. The former deposition is prevented by the use of acids, and the latter by alcalis and the alcaline earths. The modes of exhibiting these remedies, and the effects which they produce, I have described in a paper printed in the *Quarterly Journal of Science and Arts*, Vol. vi.

1989. Urinary calculi are, for the most part, composed of materials that exist at all times in the urine, though there are a few substances that only make their occasional appearance in them. The following are their component ingredients:

1. Uric acid.
2. Urate of ammonia.
3. Phosphate of lime.
4. Ammonio-magnesian phosphate.
5. Oxalate of lime.
6. Carbonate of lime.
7. Cystic oxide.

1990. The calculi composed of uric acid, of which the chemical properties have already been described (1975), are of a brown or fawn-colour; and, when cut through, appear of a more or less distinctly laminated texture. Their surface is generally smooth, or nearly so, being sometimes slightly tuberculated. Before the blow-pipe this calculus blackens, and gives out a peculiar ammoniacal odour, leaving a minute portion of white ash: it is soluble in solution of pure potassa, and heated with a little nitric acid, affords the fine pink compound, above-mentioned (1976).

1991. Phosphate of lime calculus is of a pale brown, or grey colour, smooth, and made up of regular and easily separable laminæ. It is easily soluble in muriatic acid and precipitated by pure ammonia, and does not fuse before the blow-pipe. *Calculi from the prostate gland*, are always composed of phosphate of lime.

1992. The ammonio-magnesian, or triple calculus, is generally white, or pale grey, and the surface often presents minute crystals; its texture is generally compact, and often somewhat hard and translucent; heated violently by the blow-pipe, it exhales ammonia, and leaves phosphate of magnesia. It is more easily soluble than the preceding, and oxalate of ammonia forms no precipitate in its muriatic solution.

1993. It frequently happens that calculi consist of a mixture of the two last-mentioned substances, in which case they melt before the blow-pipe, and are hence termed *fusible calculi*. They are white or nearly so, and softer than the separate substances, often resembling chalk in appearance. They are easily soluble in muriatic acid, and if oxalate of ammonia be added to their solution, the lime is precipitated in the state of oxalate.

1994. Oxalate of lime forms calculi, the exterior colour of which is generally dark brown, or reddish; they are commonly rough, or tuberculated upon the surface, and have hence been called *mulberry calculi*. Before the blow-pipe they blacken and swell, leaving a white infusible residue, which is easily recognised as quicklime (1721). Small oxalate of lime calculi are, however, sometimes perfectly smooth upon the surface, and much resemble a hempseed in appearance.

1995. Urate of ammonia I admit among urinary calculi, upon the authority of Dr. Prout, my own experiments having formerly induced me to doubt its existence (*Phil. Trans.* 1808). Its surface is sometimes smooth, sometimes tuberculated; it is made up of concentric layers, and its fracture is fine earthy, resembling that of compact limestone; it is generally of a small size, and rather uncommon, though it often occurs mixed with uric acid. It usually decrepitates before the blow-pipe, is more soluble than the uric calculus, evolves ammonia when heated with solution of potassa, and is readily soluble in the alcaline carbonates, which pure uric acid is not.

1996. Dr. Prout and Mr. Smith (*Med. et Chir. Trans.* xi. 14.) have described calculi composed almost entirely of carbonate of lime, but this species is exceedingly rare,and among several hundred calculi which I have examined, I never met with it from the human bladder.

1997. Cystic oxide is a peculiar animal substance; the calculi composed of it, which are rare, are in appearance most like those of the ammonio-magnesian phosphate. They are soft, and when burned by the blow-pipe, exhale a peculiar fœtid odour. They are soluble in nitric, sulphuric, muriatic, phosphoric, and oxalic acids, and also in alcaline solutions.

1998. The substances which have been described, with the exception of cystic oxide, are sometimes intimately blended in calculi; sometimes they form alternating layers; and in a few cases four distinct layers have been observed, the nucleus being uric, upon which the oxalate, and phosphate of lime, and the triple phosphate, are distinctly and separately arranged.

1999. Dr. Marcet has described a calculus composed of a peculiar animal matter, which he calls *Xanthic Oxide*, from its property of giving a yellow colour when acted on by nitric acid: he has also announced the existence of calculus composed of *fibrine.—Essay on Calculous Disorders, 2d edit.* p. 103.

2000. These are the principal chemical facts belonging to the history of urinary calculi. In Dr. Wollaston's valuable papers upon this subject (*Phil. Trans.* 1797 and 1810,) much additional information will be found. In the same work (1806, 1808, and 1810,) I have given some account of their peculiarities, depending upon their situation, and have also discussed the operation of solvents, a subject which I have taken up more in detail in the *Quarterly Journal of Science and the Arts*, Vol. viii.

Dr. Marcet and Dr. Prout have also published excellent dissertations on *Calculous Disorders*, containing all that is most important upon the subject.

SECTION VII. *Cutis, or Skin ; Membrane*, &c.

2001. THE skin of animals consists of an exterior albuminous covering, or *cuticle*, under which is a thin stratum of a peculiar substance, called by anatomists *rete mucosum*, and which lies immediately upon the *cutis*, or true skin, of which the principal component is *gelatine*.

2002. The following are the chemical properties of pure gelatine. It is colourless, semi-transparent, and nearly tasteless. It is softened by long-continued immersion in cold water : in hot water it readily dissolves, and forms a solution of as lightly milky appearance, which, if sufficiently concentrated, concretes on cooling into the tremulous mass usually called *jelly*, and which is easily soluble in cold water ; when dried in a gentle heat it acquires its original appearance, and is as soluble as before. When dry, gelatine undergoes no change, but its solution soon becomes mouldy and putrescent. Submitted to the action of heat, it affords the usual products of animal substances.—HATCHETT. *Philos. Transact.* Vol. xc.

It is readily soluble in diluted acids and alcaline solutions, and forms no soap with the latter. Its aqueous solution is not affected by solution of corrosive sublimate, and few of the metallic salts occasion any precipitate in it. Chlorine passed through its solution, occasions a white elastic matter to separate, which is not soluble in water, and which in some properties resembles albumen. It is insoluble in alcohol and ether. Solution of tannin occasions a white precipitate in solution of gelatine; and hence, vegetable astringents, such as galls or catechu, are generally employed as tests for its presence. But as tannin precipitates albumen, it cannot be relied on as an unequivocal test, unless we previously ascertain the non-existence of albumen by corrosive sublimate.—BOSTOCK. NICHOLSON'S *Journal*, xiv. and xxi.

Mr. E. Davy recommends sulphate of platinum as a very delicate test of gelatine, with which it forms a brown insoluble compound, in solutions too weak to be affected by vegetable astringents.—*Phil. Trans.* 1820, p. 119.

2003. The action of sulphuric acid upon gelatine has been investigated by M. Braconnot. Twelve parts of powdered glue and 24 of sulphuric acid, were left together for 24 hours; about 60 parts of water were then added, and the whole boiled for 5 hours, adding water at intervals; the solution was then saturated with chalk, filtered, and suffered to evaporate spontaneously. In a month crystals were deposited, which, being purified by solution and a second crystallization, much resembled sugar of milk, though they differ from that substance in affording a peculiar acid, called by M. Braconnot *Nitro-*

saccharine acid, when acted upon by nitric acid.—*Ann. de Chimie et Phys.*, xiii.

2004. The different kinds of gelatine differ considerably in viscidity. Mr. Hatchett has remarked that the gelatine obtained from skins possesses a degree of viscidity inversely as their softness or flexibility; the most adhesive kinds of gelatine, too, are less easily soluble in water than those which are less tenacious. The principal varieties of gelatine in common use are,

a. Glue, which is prepared from the clippings of hides, hoofs, *&c.*, obtained at the tan-yard; these are first washed in lime-water, and afterwards boiled and skimmed; the whole is then strained through baskets, and gently evaporated to a due consistency; afterwards it is cooled in wooden moulds, cut into slices, and dried upon coarse net-work. Good glue is of a semi-transparent and deep brown colour, and free from clouds and spots. When used it should be broken into pieces, and steeped for about 24 hours in cold water, by which it softens and swells; the soaked pieces may then be melted over a gentle fire, or in a water-bath, and in that state applied to the wood by a stiff brush. Glue will not harden in a freezing temperature, the stiffening depending on the evaporation of its superfluous water.

b. Size is less adhesive than glue, and is obtained from parchment shavings, fish-skin, and several animal membranes. It is employed by bookbinders, paper-hangers, and painters in distemper, and is sometimes mixed with flour, gum, *&c.*

c. Isinglass is prepared from certain parts of the entrails of several fish; the best is derived from the sturgeon, and is almost exclusively prepared in Russia.

It should be free from taste and smell, and entirely soluble in warm water, which is seldom the case, in consequence of the presence of some albuminous parts. When the jelly of isinglass is concentrated by evaporation and carefully dried, it forms a very choice kind of glue.—AIKIN's *Dictionary*, Art. GELATINE.

2005. *Leather* is a compound of gelatine and vegetable astringent matter, formed by steeping the skins of animals in the infusions of certain barks. The skins are previously prepared by soaking in lime-water, which renders the cuticle and hair easily separable, and are afterwards softened by allowing them to enter into a degree of putrefaction. In this state they are submitted to the action of infusion of oak-bark, or other astringent vegetable matter (1587), the strength of which is gradually increased until a complete combination has taken place, which is known by the leather being of an uniform brown colour throughout; whereas, in imperfectly tanned leather a white streak is perceptible in the centre.

Tawed leather is made by impregnating the skin duly prepared, with a solution of alum and common salt; it is afterwards trodden in a mixture of yolk of eggs and water.

Curried leather is made by besmearing the skin, or leather, while yet moist, with common oil, which, as the humidity evaporates, penetrates into the pores of the skin, giving it a peculiar suppleness, and making it, to a considerable extent, water-proof. As familiar examples of these processes, the thick sole-leather for shoes and boots is *tanned;* the upper-leather is *tanned* and *curried;* the white leather for gloves is *tawed;* and fine Turkey-leather is *tawed,* and afterwards slightly *tanned.* —AIKIN's *Dictionary*, Art. LEATHER.

2006. The different *membranes* of the body, and the *tendons*, are chiefly composed of gelatine, for by long digestion in warm water they gradually soften, and become ultimately almost perfectly soluble.

SECTION VIII. *Muscle, Ligaments, Horn, Hair, &c.*

2007. WHEN the *muscular parts* of animals are washed repeatedly in cold water, the fibrous matter which remains consists chiefly of albumen, and is in its chemical properties analogous to the clot of blood (1942). Muscles also yield a portion of gelatine; and the flesh of beef, and some other parts of animals, afford a peculiar substance of an aromatic flavour, called by Thenard, *osmazome*.

2008. 30 parts of beef fibre, acted on by as much sulphuric acid, yielded M. Braconnot a portion of fat, and on diluting the acid mixture, and saturating with chalk, filtering, and evaporating, a substance, tasting like osmazome was obtained, which was often boiled in different portions of alcohol: the alcoholic solutions, on cooling, deposited a peculiar white pulverulent matter, which Braconnot calls *leucine*, and which acted upon by nitric acid, affords a crystallizable *nitroleucic acid*.—*Annales de Chimie et Phys.*, xiii. p. 118.

2009. *Ligaments*, *horn*, *nail*, and *feathers*, consist principally of albumen.

2010. *Hair* consists principally of a substance, having the properties of coagulated albumen. It also contains gelatine, and the soft kinds of hair yield it more readily than those which are harsh, strong, and elastic.—HATCHETT. *Phil. Trans.* 1800.

Vauquelin discovered in hair two kinds of oil; the one white, and existing in all hair; the other coloured, yellow from red hair, and dark coloured when obtained from dark hair. Black hair also contains iron and sulphur. He supposes that where hair has become suddenly gray, the effect is produced by the evolution of acid matter, which has destroyed the colour of the oil.

2011. *Feathers, quills*, and *wool*, are also possessed of the properties of albumen, and appear to contain no gelatine.

SECTION IX. *Fat, Spermaceti, &c.*

2012. THE fat of animals, when freed by fusion or pressure from cellular membrane, is of various degrees of consistency, as seen in *tallow, lard*, and *oil*. When pure, it has little taste or smell, but it acquires both by keeping, and becomes rancid and slightly sour. The softer varieties fuse at about 90°, and the harder at 120°. Decomposed at a red heat, they afford abundance of olefiant gas, and a small portion of charcoal; products analogous to those of vegetable oil. (741.)

When burned, they produce water and carbonic acid, containing the same ultimate elements, in the same proportions as vegetable oils. (1619.)

They also produce soaps by combination with alcalis.

Nitric acid, heated in small quantity with any of the fatty substances, renders them harder, and considerably increases their solubility in alcohol. Among the vegetable oils this change is most remarkably produced upon cocoa-nut, and castor-oils, the latter becoming converted into a solid matter, which, when cleansed of adhering acid by washing, resembles soft wax.

2012. The experiments of Braconnot and Chevreul, already quoted (1613) have shown that the different kinds of oil and fat contain two substances, to which they have given the names *stearine* and *elaine*, the former solid, the latter liquid at common temperatures. The following table shows their relative proportions in different fats and oils:

	Elaine.	Stearine.
Butter, made in summer	60	40
Ditto, winter	37	63
Hogs'-lard	62	38
Beef-marrow	24	76
Mutton ditto	74	26
Goose-fat	68	32
Ducks'-fat	72	28
Turkeys'-fat	74	26
Olive-oil	72	28
Almond-oil	76	24

These principles may be obtained by boiling hogs'-lard in alcohol; the fluid, on cooling, deposits a crystalline matter, which is to be purified by a second solution and crystallization; it is then pure *stearine*, white, brittle, tasteless, and inodorous; it fuses at a little below 120°, and forms soap with alcalis.

When the alcohol which has deposited the whole of the stearine is distilled, an oily liquid remains, which is *elaine*. It is fluid at 58°; it generally is of a yellow colour, and is convertible into soap.

2013. When soap composed of hogs'-lard and potassa, is put into water, a portion only is dissolved; the remainder consists of white scales, composed of the alcali united to a peculiar acid, called by Chevreul, from its pearly appearance, *margaritic acid*, and separable from the above combination by muriatic acid.

It is insoluble in water, tasteless, fusible at 134°, and crystallizes on cooling in brilliant white needles. It is soluble in alcohol. It unites with potassa in two proportions, the one compound containing 100 acid + 8.80 potassa; the other, 100 acid + 17.77 potassa. These compounds have been termed *margarates of potassa*.

2014. The portion of the hogs'-lard soap soluble in water, consists of another peculiar substance united to potassa, which Chevreul has called *oleic acid*. It may be obtained from its solution by tartaric acid, which causes it to separate in the form of an oily matter, that is to be again united to potassa, and separated as before. This substance solidifies at about 40°, and it forms compounds, called *oleates*. It appears probable that, by the action of alcalis, the stearine is converted into what Chevreul has termed margaric acid, and the elaine into oleic acid.—*Annales de Chimie*, xciv.

2015. By mixing 1 volume of carbonic acid with 10 of carburetted hydrogen, and 30 of hydrogen, and passing the mixture through a red-hot porcelain tube, Berard is said to have produced a substance in small white crystals, having many of the properties of fat.—THOMSON'S *Annals*, xii.

2016. *Spermaceti* or *Cetine* is a peculiar matter, which concretes from the oil of the *spermaceti whale.* It fuses at 112°, and at higher temperatures is volatile, but if repeatedly distilled it loses its solid form, and becomes a liquid oil. It is soluble in boiling alcohol, and abundantly so in ether. It forms a soap with potassa, which yields, on decomposition, a substance called by Chevreul, *cetic acid.*—*Annales de Chimie*, xcv.

2017. In the *yolk* of *eggs* there is a considerable quantity of oily matter, which may be obtained by pressure after boiling; it is yellow and tasteless.

2018. *Ambergris*, which is a concretion from the intestines of the spermaceti whale, also contains a considerable portion of fatty matter, amounting in some specimens to 60 *per cent.* It is only found in the unhealthy animal.—HOME'S *Lectures on Comparative Anatomy*, Vol. i., p. 470.

2019. The brain of animals, when boiled in alcohol, furnishes a peculiar fatty matter, which the solution deposits as it cools, in brilliant scales. It requires a higher temperature than that of boiling water for its fusion, and appears in many respects analogous to cholesterine. (1959.) The same substance is often seen in the alcohol employed to preserve anatomical preparations of the brain and nerves.

SECTION X. *Cerebral Substance.*

2020. ACCORDING to Vauquelin, the *cerebral substance* consists of

Water	80.00
White fatty matter	4.53
Red fatty matter	0.70
Albumen	7.00
Osmazome	1.12
Phosphorus	1.50
Acids, salts, and sulphur	5.15
	100

The *pulp of nerves* seems to be of a similar nature.—THOMSON'S *System,* Vol. iv., p. 482.

SECTION XI. *Shell and Bone.*

2021. WE are indebted to Mr. Hatchett for two excellent dissertations on the chemical properties of these parts of animals, published in the *Philosophical Transactions* for 1799 and 1800.

He has divided *shells* into two classes; the texture of the first is compact, brittle, and resembling porcelain; their surface is smooth, and they are often beautifully variegated. When exposed to a red heat they crackle, and lose the colour of their enamelled surface, emitting scarcely any smoke or smell. They dissolve in dilute muriatic acid with copious effervescence, and form a transparent solution, in which neither pure ammonia nor acetate of lead produce any precipitate, but carbonate of ammonia throws down carbonate of lime. Hence these, which are called *porcellaneous shells*, may be considered as composed of carbonate of lime, united to a very small portion of gelatine: most of the univalve shells, such as whelks, limpets, cowries, and many of the beautiful convoluted shells of tropical countries, belong to this class.

2022. The second class, or *mother-of-pearl shells*, are tougher, glossy, and iridescent; they are mostly bivalves, and all the oyster and muscle species belong to it. When heated, they exhale smoke and the smell of burned horn; immersed in muriatic acid, they only partially dissolve, and leave a series of cartilaginous layers, and an outer epidermis. Each membrane appears to have a corresponding stratum of carbonate of lime, the solution indicating no trace of any phosphate. The animal part is in some cases, as in mother-of-pearl, tough and indurated, and when dried becomes exactly like horn; in other instances, as in the bone of the cuttle fish, it appears in the form of delicate and tender membrane.

In both classes of shells, therefore, the hardening principle is carbonate of lime; in porcellaneous shells there is very little animal matter, which is gelatine; and in mother-of-pearl shells, it is albumen, and in larger quantities.

2023. *Pearls* are exactly similar in composition to what is termed *mother-of-pearl,* in which Mr. Hatchett found

Carbonate of lime..........	66
Albumen	24
	100

2024. In the *scales of fish,* and in the *crusts* of lobsters, crabs, prawns, and cray-fish, Mr. Hatchett found the animal portion to consist of cartilage; the hardening part was a mixture of carbonate and phosphate of lime. From *lobster-shell* Merat-Guillot obtained

Carbonate of lime..........	60
Phosphate of lime..........	14
Cartilage	26
	100

Vauquelin obtained from 100 parts of *hen's egg-shell*

Carbonate of lime........	89.6
Phosphate of lime........	5.7
Animal matter	4.7
	100

2025. *Zoophytes,* according to Mr. Hatchett's researches, may be divided into four classes; the first resemble porcellaneous shells, and consist entirely of carbonate of lime, with a very minute quantity of gelatinous matter; of this the common white coral (*madrepora virginea*) is an example. The second consists of carbonate of lime, and a cartilaginous substance, and are therefore analogous to mother-of-pearl shell;

to this class belong the *madrepora ramea*, and *madrepora fascicularis*. The third class is composed of a cartilaginous matter, with carbonate and phosphate of lime; to this belongs the red coral (*gorgonia nobilis*). The fourth class contains sponges, composed almost entirely of albuminous matter.—*Phil. Trans.*, 1800.

2026. *Bone*, and *Ivory*, like the preceding substances, is essentially composed of soft and hard parts. When ground bone is digested in warm water, a portion of fat is first separated, and by long-continued ebullition, a solution which gelatinizes on cooling is obtained. If fresh bone be immersed in diluted muriatic acid, the fat, gelatine, and hardening matter are dissolved, and a kind of skeleton of the bone remains in the form of a cartilaginous substance, which when dried exactly resembles horn. It appears, therefore, that the soft parts of bone are, *fat*, *gelatine*, and *albumen*.

The earthy salts, which constitute the hardening principle of bone, are phosphate and carbonate of lime, with a minute quantity of sulphate of lime, and traces of phosphate of magnesia. Fourcroy and Vauquelin obtained from ox-bones,

Animal matter	51
Phosphate of lime	37.7
Carbonate of lime	10
Phosphate of magnesia	1.3
	100

2027. The *enamel of teeth* is perfectly destitute of cartilage, and consists chiefly of phosphate of lime and a portion of gelatine. Mr. Pepys found its component parts

Phosphate of lime	78
Carbonate of lime	6
Gelatine	16
	100

The same chemist has given the following as the composition of the teeth (Fox, *On the Teeth*):

	Roots of the Teeth.	Teeth of Adults.	First Teeth of Children.
Phosphate of lime	58	64	62
Carbonate of lime	4	6	6
Cartilage	28	20	20
Loss	10	10	12
	100	100	100

2028. When bones are submitted to destructive distillation, the gelatine and albumen which they contain is abundantly productive of ammonia; water, and carbonic acid are also formed and a portion of highly fœtid empyreumatic oil. There remains in the vessel a quantity of charcoal mixed with the earthy substances, which is, in that state, called *ivory black*. It is employed as the basis of some black paints and varnishes.

SECTION XII. *Of Animal Functions.*

2029. CHEMISTRY has hitherto done little towards elucidating the functions of animals, and it is scarcely possible to describe the little that has been done, without such frequent reference to anatomical and physiological inquiries as would be irrelevant to the present work; I shall, therefore, only enumerate the principal chemical phænomena that have been experimentally illustrated, in relation to this subject.

2030. *Digestion* is a process by which the food of animals is converted into chyle, and which, in conjunction with *respiration*, tends to the production of blood. The mechanism by which it is carried on differs considerably in the different classes of animals; the present remarks will relate chiefly to man, and to the carnivorous tribe.

The food, duly masticated in the mouth, and blended with a considerable portion of saliva, is propelled into the stomach, where it soon undergoes a remarkable change, and, in the course of a few hours, is converted into an apparently homogeneous pulpy mass, which has been termed *chyme*, and which has little or no resemblance to the original food. This very curious change is only referable to the operation of a secretion peculiar to certain glands of the stomach; it has been termed *gastric juice*, and all that is known respecting it is, that it has very energetic solvent powers, in regard to the greater number of animal and vegetable bodies; the remarkable property of living substances to resist its action is curiously illustrated by the circumstance that the stomach itself, after death, is occasionally eaten into holes by its action; it instantly coagulates all albuminous substances, and afterwards softens and dissolves the coagulum. There are some substances that remarkably resist its action, such as the husk of grain, and of many seeds, which, if not previously broken by mastication, pass through the stomach and bowels nearly unaltered. It is hardly worth while to detail the experiments that have been undertaken on the gastric juice, since they are much at variance, and it is impossible to say whether the secretion has ever been examined in a state even approaching to purity. It has been described as a glairy fluid, of a saline taste; sometimes it is said to be acid, and sometimes bitter; but no light whatever has been thrown by any of these researches upon the cause of its singular solvent energies.

It has sometimes been matter of surprise, that although animals drink copiously with their food, the consistency of the chyme is not affected by it, and by the time that it reaches the right, or pyloric extremity of the stomach, the liquid has disappeared. Sir Everard Home's curious physiological researches have shown that liquids are copiously and rapidly removed by adsorbents belonging principally to the left, or cardiac portion of the stomach, and that during digestion there is an imperfect division of the stomach into two cavities, by the contraction of the bands of muscular fibres about its centre. He has also shown that these liquids very soon reach the kidneys, and pass off by urine; and was led to believe that the spleen was the channel of communication; an opinion, however, which his subsequent researches tended to disprove.—*Lectures on Comparative Anatomy*, p. 221.

The chyme passes from the stomach into the small intestines, where it soon changes considerably in appearance; it becomes blended with bile, and is separated into two portions, one of which is white as milk, and is termed *chyle;* the other passes on to the large intestines, and is ultimately voided as excrementitious. The chyle is absorbed by the *lacteals,* which terminate in the common trunk, called the *thoracic duct;* it is there mixed with variable proportions of lymph, and poured into the venous system.

The *excrements of animals* have been examined by Berzelius, (GEHLEN'S *Journal,* vi.); by Vauquelin, (*Annales de Chimie,* xxix.); and by Thaer and Einhoff. An abstract of these experiments has been published by Dr. Thomson, in the 4th volume of his *System of Chemistry.*

2031. *Chyle* has been examined by several chemists, and their results are not widely different. During some physiological researches in which I assisted Mr. Brodie, I had an opportunity of collecting it in considerable quantities in several carnivorous and graminivorous animals, and presented an account of my experiments upon it to the Royal Society.—*Phil. Trans.,* 1812, p. 91.

Chyle is an opaque white fluid, having a sweetish saline taste; its specific gravity is inferior to that of the blood. It exhibits slight traces of alcaline matter when tested by infusion of violets; soon after removal from the thoracic duct, it gelatinizes spontaneously, and afterwards gradually separates into a firm yellowish white coagulum, and a transparent colourless serum; so that, like the blood, it enjoys the property of spontaneous coagulation.

The *coagulum of chyle* possesses properties closely resembling those of the caseous portion of milk, and may hence be considered as a variety of albumen; the *serum of the chyle*, when heated, deposits a few flakes of albumen, and by evaporation to dryness affords a small proportion of a substance analogous to sugar of milk. Small portions of phosphate of lime, carbonate of soda, and common salt, may also be detected in the chyle. In these experiments I found no distinctive difference in the chyle of graminivorous and carnivorous animals; I examined it from the horse, the ass, the dog, and the cat; Dr. Marcet thinks that the former is less abundant in albumen than the latter*.—THOMSON'S *Annals*, Vol. vii.

2032. There can be little doubt that the bile performs an important part in the change which the chyme suffers in the small intestines; it has been conjectured that its aqueous, and perhaps its alcaline, parts, are employed as components of chyle, while the albumino-resinous matter combines with the excrementitious portion, and tends to stimulate the intestinal canal towards promoting its propulsion. Whether the bile is absolutely necessary to the formation of chyle, is a question that has not been satisfactorily answered; but its importance is demonstrated by the emaciation that attends its deficiency, and by the disordered state of bowels that accompanies its imperfect secretion. Sir Everard Home, in his *Lecture on the Functions of the Lower Intestines*, (*Lectures*, p. 468.) has offered some curious facts connected with this subject, to which I refer the physiological reader. He is of opinion that, in the large intestines, a portion of the food unfit for chylification is, by a process not widely different from that above described, (1936) converted into fat, which is afterwards absorbed and conveyed to different parts of the body.

---

* It is a curious question, whence the nitrogen, which constitutes an abundant ultimate principle of the chyle of herbivorous animals, is derived; we find it in very small proportion only in their ordinary food, and yet I could discern no difference in the composition of the albuminous portion of their chyle, and that of animals fed exclusively on meat.

2033. In chyle we cannot fail to observe a close approximation to blood: it is deficient only in colouring matter, and the albumen which it contains differs a little from that existing in the blood itself; it appears, therefore, that the albumen is perfected, and the colouring matter formed, in the process of circulation; the saccharine principle of the chyle is also no longer perceptible.

2034. The difference between arterial and venous blood, has been adverted to in a previous section; the former is of a florid red colour, and circulates in the arterial system; it is contained in the left ventricle of the heart, and thence carried by the *aorta*, and its ramifications, to every part of the body, tending to re-production and secretion: it afterwards enters the veins which arise from the extremities of the arteries, and form accompanying branches and trunks ultimately uniting in the *venæ cavæ*, which pour their contents into the right auricle of the heart; the venous blood is thence propelled into the right ventricle, from which the pulmonary artery arises, transmitting it through the lungs, whence it is returned by the pulmonary vein into the left auricle, which transmits it to the left ventricle, from which issues the aorta as aforesaid. So that the right cavities of the heart receive venous blood, and transmit it through the lungs, whence it returns to the left side of the heart, in the arterial state. In the lungs the blood is infinitely subdivided, and spread over a very large surface in vessels so delicate as to admit of the operation of the atmospheric air contained in their cells; it enters the pulmonary structure in the *venous* state by the *pulmonary artery*, and returns in the *arterial* or *aërated* state, by the *pulmonary vein*. It now remains to examine the changes which the blood undergoes during pulmonary circulation.

2035. *Respiration* is the process of receiving a quantity of air into the lungs, whence, after having been retained a short time, it is again expelled in the action of exspiration; and, if now examined, a portion of its oxygen is found converted into carbonic acid, and it is more or less loaded with aqueous vapour.

Obvious circumstances render it very difficult to ascertain the quantity of air taken into the lungs at each natural inspiration, as well as the number of respirations made in a given time; the former is perhaps about 15 or 16 cubic inches, and the latter about 20 in a minute.

It has been by some supposed that the air suffers an absolute diminution of bulk, but the experiments that have been adduced to prove this, can, I think, scarcely be regarded as satisfactory; it seems, on the contrary, most probable that the volume of air expired is exactly equal to that inspired, and consequently the only chemical change that is evident is the saturation of a portion of its oxygen with carbon. The quantity of carbonic acid emitted at each exspiration, varies at different periods of the day, and probably also in different individuals; it appears at its maximum during digestion, and at its minimum in the morning, when the stomach is empty, and when no chyle is flowing into the blood. Dr. Prout has shown that fermented liquors and vegetable diet diminish the proportion of carbonic acid, and that the same thing happens when the system is affected by mercury. (THOMSON's *System*, iv. 621.)

The air expired may be regarded, I think, as containing, on an average, 3.5 *per cent.* of carbonic acid, though Messrs. Allen and Pepys, in their valuable *Essay on Respiration*, (*Phil. Trans.*, 1808.) have estimated it at about twice that quantity; it amounted, in their experiments, to 27.5 cubic inches per minute, a quantity probably above the truth, when we reflect upon the comparative proportion of carbon existing in our food, and the other means of escape which it has from the body.

The aqueous vapour contained in the expired air is secreted by the exhalents distributed over the surface of the air-vessels of the lungs; attempts have been made to estimate its quantity, but without success; it is probably liable to variation, and can scarcely be considered as a product of respiration.

It has been above stated that the whole of the venous blood is propelled through the vessels of the lungs, where it is subjected to the action of the air; the chyle is of course carried along with it, and when it returns by the pulmonary vein to the left side of the heart, it has undergone a considerable change in appearance, having lost its dingy colour, and acquired a fine florid red; the chyle also has become perfect blood. The change of colour is evidently owing to the action of the air, which takes place through the thin coats of the circulating vessels, and the end thus attained is the removal of the carbon from the venous blood, by which the colouring matter was obscured; the carbon to be thus readily soluble in oxygen must be in some peculiar state; a portion of it is also removed by the absorbents, and transferred to the glands situate at the root of the lungs between the subdivisions of the bronchiæ, which often contain a large portion of black matter. This has sometimes been referred to soot inhaled with the air, but many circumstances render it more probable that it is a carbonaceous deposit from the blood. The only chemical difference, then, which can be detected between arterial and venous blood, is the existence of a certain excess of carbon in the latter, which it gives off to oxygen, forming carbonic acid; the blood is thus fitted for the renovation of parts, for the formation of secretions, and for the sustenance of life by its action on the cerebral system; for although the heart does not directly refuse to circulate venous blood, paralysis and torpor ensue when blood, not aërated, passes into the vessels of the brain.

2036. It has already been shown that the blood suffers very important changes in the kidneys and liver; the function of *perspiration* also must be considered as connected with an alteration of the circulating fluid, for moisture, carbonic acid, and minute quantities of phosphoric acid, and saline matter, among which is common salt, are evacuated by the cutaneous vessels. This quantity of humidity is sometimes very considerable, especially during violent exercise in warm weather, and it contributes materially to diminish the temperature of the body; a portion of water, however, is at all times passing off by the skin, as may be seen by putting the hand into a dry and cold glass, which soon becomes dimmed by the condensation of vapour.

2037. Different animals require very different quantities of oxygen for the purposes of respiration. Man, and warm-blooded animals, consume the largest quantity; the amphibious tribes not only require less, but can breathe in an atmosphere which will not support the life of the former; and many insects take such small quantity, as sometimes to have been supposed capable of living without air, which is not the case. In the production of carbonic acid all animals agree, and consequently the nature of the deterioration suffered by the air is similar throughout the animal creation.

Fishes breathe the air which is dissolved in water; they therefore soon deprive it of its oxygen, the place of which is supplied by carbonic acid; this is in many instances decomposed by aquatic vegetables, which restore oxygen, and absorb the carbon (1520); hence the advantage of cultivating growing vegetables in artificial fish-ponds. It has been ascertained by Biot, and verified by others, that the air-bladders of fish that live in very deep water are filled with a mixture of oxygen and nitrogen, in which the former greatly preponderates; but in fish that are taken near the surface, the nitrogen is most abundant. In the *trygla lyra*, always caught in very deep water, the air-bladder contained 87 *per cent.* of oxygen: in the carp and roach, according to Fourcroy and Priestley, the air-bladder contains little else than nitrogen.—Biot, *Mémoires d'Arcueil*, i. & ii.

2038. The production of *animal heat* is perhaps the most recondite of all the functions; the power appears to belong to all animals, though to some in a very inferior degree. The higher orders of animals always maintain a temperature of about 100°; it varies a little in different parts of the body, the extremities and surface being a degree or two colder than the interior vital organs. This temperature is probably very little affected by external circumstances, a hot or cold atmosphere producing no corresponding change in the heat of the circulating blood.

When the chemical changes that take place during respiration had been inquired into, and when it was found that the capacity of carbonic acid for heat was less than that of oxygen, it was supposed that the conversion of oxygen into carbonic acid was the cause of the rise of temperature: and as the heat of the lungs does not exceed that of other parts, it was asserted that the air was absorbed by the blood, and that the production of carbonic acid, and consequent evolution of heat, took place gradually during the circulation. To these opinions many strong objections have from time to time been urged by different physiologists, but their complete subversion followed the researches of Mr. Brodie, (*Phil. Trans.*, 1812.) who found that the heart was capable of retaining its functions for some hours, and of carrying on circulation in a decapitated animal, and consequently independent of the influence of the brain, when respiration was artificially carried on. Under these circumstances it was observed, that, although the change of blood from the venous to the arterial state was perfect, no heat was generated, and that the animal cooled regularly and gradually down to the atmospheric standard. In more than one instance I examined, at his request, the expired air, and found that it contained as much carbonic acid as was produced by the healthy animal; so that here, circulation went on, there was the change of oxygen into carbonic acid, and the alteration of colour in the blood, and yet no heat whatever appeared to be generated.

In these cases a period was also put to the secretory functions; and it has been observed by other physiologists, that if the nerves that supply any of the glands are injured or divided, there is a corresponding change or suspension of their secretion. Electricity has sometimes been supposed to have some connexion with the nervous influence, and the fact of some of the secretions being alcaline, while others are acid (corresponding to negative and positive influence), has been adduced in favour of the supposition*; but experiment has gone little way to sanction such a notion, and although it has been proved that the nervous influence contributes to the generation of heat in animals, that it presides over the phænomena of secretion, as well as of voluntary motion, the actual cause of this influence, or energy, remains among those mysteries of nature which, doubtless, for the wisest purposes, are hidden to the human understanding.

---

* In the *Philosophical Transactions* for 1809, p. 385, Sir Everard Home has given an account of these views, in a paper entitled *Hints on the Subject of Animal Secretions.*

CHAPTER X.

GEOLOGY.

2039. Having detailed the properties of the elementary bodies, and of their natural and artificial combinations, and having described the products of the vegetable and animal creation, it remains in this, the concluding chapter, to notice the general arrangements of the mineral world, to describe the mutual relations of the substances constituting the surface of our globe, and to examine their characters and composition: these investigations form the object of geological science.

SECTION I. *General Remarks on the Objects of Geological Science—Sketch of the Theories of Burnet, Woodward, Leibnitz, Whiston, Whitehurst, and Buffon.—Wernerian and Huttonian Theories.*

2040. GEOLOGY embraces so many topics of discussion, its range is so extensive, and the meanings given to the term are so various and opposite, as to throw no inconsiderable difficulties in his way who would enumerate and expound them. Persons have been called geologists, who, gifted with prolific imaginations, have indulged in fanciful speculation concerning a former order of things, and have reared hypotheses respecting the origin of our planet, upon foundations so flimsy and unsubstantial, as to deserve no other appellation than flighty excursions of a poetic mind. Others, by careful, diligent, and extended observations of the present state of the earth's surface, have endeavoured, in the path of induction, to trace the nature of the agents which have once been active, to ascertain how far they are now operating, and to anticipate the results of their continuance. If they frame theories, they do so upon the results of actual research; if they indulge in speculation, they assign to it its proper place. These are really geologists, and their aim is, not to imagine or suppose, but to *discover* the nature of all changes of the earth's surface and interior, and thence to arrive at the laws that regulate them.

Geology, as a branch of inductive science, is of very modern date; for though the attention of men has long been turned to a theory of the earth, the formation of such a theory is incompatible with any but an advanced state of physical knowledge. There appear, indeed, few studies of more difficulty; none in which the subject is more complex; appearances so diversified and scattered; and where the causes that have operated are so remote from the sphere of ordinary observation.

2041. The first writer upon this subject, whose name merits notice, is Thomas Burnet*, who may justly be said to have adorned the latter half of the seventeenth century. And though it be true that his pen has rather recorded the sallies of a vivid imagination, than the inferences of sober argument, he will still be read with some profit, though certainly with more pleasure, even in these times. The objection to Burnet and his contemporaries, and immediate successors, is, that they fancifully go back to the chaotic state of the earth, and after enlarging, embellishing, and obscuring the Mosaic history, they pretend to have illustrated and proved it. Accordingly, Burnet, in his *Sacred Theory of the Earth*, begins with the separation of elements from a fluid mass. The heaviest particles sank, and formed a nucleus, and water and air took their respective stations: upon the water, however, the air afterwards deposited a rich unctuous crust, which begat vegetation, and a beautiful verdure clothed the whole.

---

* *The Sacred Theory of the Earth, containing an Account of the Original of the Earth, and of all the General Changes which it hath already undergone, or is to undergo, till the Consummation of all Things.* (8vo., London, 1726.) Published originally in Latin in 1681 and 1689.

There were no mountains, no seas, no protuberances, or inequalities; and the equator being coincident with the plane of the ecliptic, all the charms of spring were perpetual. This state of things, however, did not thus continue for many centuries; for the sun caused large cracks and fissures in the exterior, which, by gradual increase, extended to the great aqueous abyss; the waters rose higher and higher, the surface was utterly broken up and destroyed, and an universal deluge took place: at length dry land began again to appear, owing to a gradual subsidence of the waters, which retired into caverns and crevices originally existing in the nucleus, or formed by the disruption of the crust; upon the increasing dry land, vegetation began again to exist, and our present islands and continents were formed, while the sea still occupies in part its original bed.

I do not recite the minutiæ of Burnet's romance, nor shall I meddle with the adjustments of these and the like speculations to the records of Holy Writ. If, in the laborious path of experimental investigation, we are occasionally rewarded with the discovery of some new adaptations of causes and effects, which had before escaped notice, but which demonstrate how all things on earth are made to work together for good, the discovery strengthens our faith, and calls forth the best feelings of which the human heart is susceptible; but we must not presume to submit the aptitude of nature's arrangements to the feeble powers of human decision, to doubt her perfection because our imbecile capacities cannot attain its comprehension, or to found our proofs of the existence, or even of the attributes, of the Deity, upon the limited, imperfect, or ideal conception of the excellence of nature's works, of which the human understanding is capable.

Although Burnet's Theory, as he calls it, was a mere hypothetical product of the imagination, unsupported by a single fact, or by the slightest observed phænomenon, it excited much admiration and some discussion, and was criticised with much acrimony and some ability*; more especially by Keill, of Oxford†. His style is in general terse and elegant, though it occasionally degenerates into the predominant pomposity of the period at which he wrote. He was the translator of his own work from Latin into English. Two brief samples from the latter will be sufficient for elucidation. After observing that the obscurity and remoteness of his subject has by some been used as an argument against undertaking it, "This," says he, "does but add to the pleasure of the contest where there are hopes of victory, and success more than recompenses all the pains. No joy is more grateful to man than the discovery of truth, especially where it is hard to come by. Every man has a delight suited to his genius, and as there is pleasure in the right exercise of any faculty, so especially in that of right reasoning, which is still the greater by how much the consequences are more clear, and the chains of them more long. There is no chase so pleasant, methinks, as to drive a thought from one end of the world to the other, and never to lose sight of it till it falls into eternity, where all things are lost, as to our knowledge."

---

* By Dr. Herbert Crofte, in 1685: by Dr. Beaumont, in 1693, and by Erasmus Warren.

† *An Examination of Dr. Burnet's Theory*, &c., by J. Keill, A.M., of Baliol Coll., Oxon. Second Edition, 1734, 8vo. "He (Burnet) begins his discourse with a saying of an old heathen, that philosophy is the greatest gift that ever God bestowed on man; but it is plain to any who will be at the pains to read his book, that God has thought fit to bestow but very little of that great gift upon him, and, that the world may not say this is ill-nature, I will give them a taste of his philosophy," *&c.*

This is the general style of the *Examination.*

The following passage from Burnet's work has been highly eulogized by Steele*, and certainly it merits praise; it is a funeral oration over the globe: "Let us now," says he, "reflect on the transient glory of the earth; how, by the force of one element breaking loose on the rest, all the beauties of nature, each work of art, and every labour of man, are reduced to nothing; all that once seemed admirable, is now obliterated: all that was great and magnificent, has vanished; and another form and face of things, plain, simple, and uniform, overspreads the earth. Where are now the empires of the world? where the imperial cities, the pillars, trophies, and monuments of glory? what remains, what impressions or distinctions do you now behold? what is become of Rome, the great city; of eternal Rome, the empress of the world, whose foundations were so deep, whose palaces were so sumptuous?—her hour is come; she is wiped from the face of the earth, and buried in everlasting oblivion. But not the cities only, and the works of men's hands, but the hills and mountains, and rocks of the earth, are melted as wax before the sun, and their place is no where found; all have vanished and dropped away, like the snow that once rested upon their summits*."

---

* *Spectator*, No. 146.

Attached to the English edition of Burnet's work, above referred to, is an "Ode to the Author, by Mr. Addison," in the ordinary fulsome style of that period. The following stanza is a specimen:

Jamque alta Cœli mœnia corruunt,
Et vestra tandem pagina, (proh nefas!)
Burnette, vestra augebit ignes,
Heu! socio peritura Mundo.

It is impossible to read this quotation, without being reminded of one of the most beautiful passages in the *Art of Preserving Health*, where Armstrong has happily introduced very similar ideas:

> What does not fade? the tower that long had stood
> The crash of thunder and the warring winds,
> Shook by the slow, but sure destroyer, Time,
> Now hangs in doubtful ruins o'er its base;
> And flinty pyramids, and walls of brass,
> Descend; the Babylonian spires are sunk;
> Achaia, Rome, and Egypt moulder down;
> Time shakes the stable tyranny of thrones,
> And tottering empires rush by their own weight;
> This huge rotundity we tread grows old,
> And all those worlds that roll around the sun,
> The sun himself shall die, and ancient night
> Again involve the desolate abyss†.

I might select many more beauties from the *Sacred Theory of the Earth.* The passages I have quoted, however, show the general strain of the author, and it would be irrelevant amusement to pursue them.

2042. A very different reasoner from Burnet was Woodward; he was nothing of a poet, and not much of a philosopher; he pretends to be a matter-of-fact man; but having collected a few observations respecting the contents of strata, hastily proceeded to the erection of a theory; "to build a ship," as Lord

---

* *Burnet's Theory*, Vol. ii., p. 25.

† *Art of Preserving Health*, B. ii.

Bacon says, "with materials insufficient for the rowing pins of a boat." Woodward observed the existence of fossil shells, and remarked that the lower strata of the earth's surface were generally harder than the upper, which were of more light and pulverulent materials: whence he concluded, that, at the period of the deluge, the earth had acquired a new crust deposited upon it by the waters, in the succession of the specific gravity of the materials; the heaviest, coarsest, and hardest bodies forming what to us seem a nucleus, covered by finer and lighter deposits*.

2043. About this time Leibnitz published his *Protogæa*†; he supposes the earth to have been in a state of combustion for many ages, and at length to have gone out for want of fuel. A glassy crust was thus formed, which gave rise to sand and gravel; other kinds of earth resulted from sand and salt; and as the globe cooled, the water which had before been kept in the state of steam, assumed fluidity, and, falling to the earth, produced the ocean. The particulars of these notions are, of course, not worth reciting.

---

* Woodward applied the geological observations he had made in England to other countries. "I was abundantly assured that the circumstances of these things in remoter countries were much the same with those of ours here; that the stone and other terrestrial matter in France, Flanders, Holland, Spain, Italy, Germany, Denmark, Norway, and Sweden, was distinguished into layers, as it is in England, *&c. &c.* To be short, I got intelligence that these things were the same in Africa, Arabia, Persia, and other Asiatic provinces; in America," *&c.* See *An Essay towards a Natural History of the Earth and Terrestrial Bodies*, by John Woodward, M.D., *&c.* London, 1702.

† *Leibnitzii Opera Omnia.* Genevæ, 1768. Vol. ii. p. 199.

2044. Whiston[*] having blended the follies ot Burnet, Woodward, and Leibnitz, endeavours to conceal his imbecility under the lion's skin of mathematical calculation; and taking many things for granted, of which there is not the most distant probability, leaves us bewildered and perplexed; he is neither plausible nor amusing, and is best known as having called forth the libellous witticism of Swift.

2045. But there was a contemporary of Whiston, whose works deserve more attention; John Whitehurst[†], a native of Congleton, in Cheshire; he passed much of his time in Derbyshire, and investigated, with considerable ability, the stratification of that rich and interesting county; "hoping," as he expresses it, "to obtain such knowledge of subterraneous geography, as might be subservient to the purposes of life, by exposing new treasures which are concealed in the lower regions [‡]." In his inquiry into the original state and formation of the earth he has assiduously collected facts, among which his account of the strata of Derbyshire retains much value at the present day, though repeated investigations have since been made with all the advantages of modern improvements. And as to his theoretical views, I think it is scarcely going too far to say, that they are the best extant: for, unlike latter geologists, he first collected facts and then constructed his theories; and those who are unbiassed by speculative doctrine, and really think for themselves, will consequently accede to by far the greater number of his leading propositions.

---

[*] *New Theory of the Earth*, &c. By William Whiston, M.A. 4th Edition, London, 1725.

[†] *The Works of John Whitehurst, F.R.S.*, London, 1729. "It is my intention (says Whitehurst, in his *Preface* to the *Inquiry into the Original State and Formation of the Earth*,) to trace appearances in nature from causes truly existent; and to inquire after those laws by which the Creator chose to form the world, not those by which he might have formed it, had he so pleased."

[‡] Whitehurst particularly notices the similarity of succession in the strata of England; and in his description of Derbyshire, he mentions the resemblance of the toadstone to lava, and infers, from its appearance, situation, and effects, that it must have issued from below in an ignited state; that it must have been projected with great violence amidst the superincumbent strata, and that their displacements and irregularities are the consequence.

2046. But no one has proceeded to the forming of a theory of the earth with the pomp and circumstance of Buffon *. It merits attention, not on account of its accordance with present appearances, or as affording plausible solutions of observed phænomena, but from the eloquence with which it is adorned, the extent of information it displays, and the popularity it derived from these sources.

He supposes the planets in general to have been struck off from the sun by a comet; that they consisted of fluid matter, and thence assumed a spherical form; and that by the union of centrifugal and centripetal forces, they are restrained in their present orbits. The earth gradually cooled, and the circumambient vapours condensed upon its surface, while sulphureous, saline, and other matters, penetrated its cracks and fissures, and formed veins of metallic and mineral products. The scorified, or pumice-like surface of the earth, acted upon by water,

---

* *Histoire et Théorie de la Terre et des Epoques de la Nature.* 4 Vol. 8vo. Paris, 1800.

produced clay, mud, and loose soils; and the atmosphere was constituted of subtile effluvia, floating above all the more ponderous materials. Then the sun, and winds, and tides, and the earth's motion, and other causes, became effective in producing new changes. The waters were much elevated in the equatorial regions, and mud, gravel, and fragments were transported thither from the poles; hence, says Buffon, the highest mountains lie between the tropics, the lowest towards the poles; and hence the infinity of islands which stud the tropical seas. The globe's surface, once even and regular, became now rough and irregular; excavations were formed in one part, and land was elevated in another; and during a period of ages, the fragments of the original materials, the shells of various fish, and different other exuviæ, were ground up by the ocean, and produced calcareous strata, and other low-land depositions. These relics of marine animals we find at such heights above the present level of the sea, as to render it more than probable that the ocean once entirely overwhelmed the earth.

Of the phænomena I have hinted at, Buffon takes particular and extended notice, and draws from them a series of curious and minute conclusions; not, however, satisfactory or logical, inasmuch as many of the data they are founded upon are imaginary, not real. Every one who now contemplates the earth's surface, must trace upon it marks of the most dire and unsparing revolutions, which, from the present order of things, it appears impossible should re-occur, except by the united and continuous agency of the most active powers of destruction. This, says Buffon, arose from the soft state of the former crust of the earth; and those causes, now imbecile and slow in their operation, were then more effectually exerted, and results were obtained in a few years, for which centuries would now be insufficient.

This amusing theorist next proceeds to contemplate the production of rivers, which he regards as having cut their own way to the ocean, as gradually wearing down the mountainous lands, filling up valleys, and choking their exits into the ocean by the transportation of finely-divided materials. Thus every thing is slowly returning to its former state; the mountains will be levelled, the valleys heightened, excavations filled up, and the ocean will again cover the earth.

I shall not enter into the various confutations of these speculative notions, nor dwell upon many modern theories to which they have given rise. Pallas, Kirwan, De Luc, and others, have animadverted upon, but can scarcely be said to have improved, Buffon's hypothesis; and as we set out with granting it to be the mere fabric of imagination, it would be folly to submit it to the solemnity of philosophic criticism.

2047. Many other theories of the earth I pass over in silence, as containing nothing not to be met with in some of the already-mentioned cosmogonists. The authors have sometimes clothed their fictions in new dresses, or presented them under new forms; but, if we remove the mask, Burnet or Buffon are instantly recognised. Thus, in pretending to advance learning, they have rather obstructed it, and have accumulated hypotheses without enriching science. They deserve that censure thrown upon certain writers by Dr. Johnson, who calls them the "persecutors of students, and the thieves of time." Such at least I have found them.

There are other geological writers who have accumulated many interesting facts, and whose insulated observations are truly curious and valuable; but their general hypotheses are of so chimerical a cast, as rather to resemble Eastern allegories than European philosophy; they defy all criticism, and therefore lie out of our present track, which now leads us to review the prevailing theories of the present day. These are the inventions of Professor Werner, of Freyburgh *, and Dr. Hutton, of Edinburgh †, each of whom has been ably supported and elucidated by the proofs, illustrations, and comparative views of acute and eloquent controversialists ‡, and two sects have been formed, under the appellation of Wernerians and Huttonians. The disputes and differences of these contending geologists would now be prematurely noticed. They each profess to proceed, as rigidly as the subject allows, in the path of induction; to reject mere hypothesis, and raise their theories upon accumulated facts; and yet they arrive at conclusions diametrically opposite; upon which a clever writer remarks, "that among all the wonders geology presents to our view, the confidence of the theorists is by far the most unaccountable."

---

* *A Comparative View of the Huttonian and Neptunian Systems of Geology.* Edinburgh, 1802.

† *Theory of the Earth.* By James Hutton, M.D., F.R.S., Edinburgh, 1795. 2 Vols. 8vo.

‡ *Illustrations of the Huttonian Theory of the Earth.* By John Playfair, F.R.S., *&c.*, Edinburgh, 1802.

2048. The first principle of the Wernerian theory assumes, that our globe was once covered with a sort of chaotic compost, holding either in solution or suspension the various rocks and strata which now present themselves as its exterior crust. From some unexplained cause, this fluid began first to deposit those bodies which it held in chemical solution, and thus a variety of crystallized, or *primitive rocks*, were formed. In these we find no vegetable or animal remains, nor even any rounded pebbles; but in the strata which lie upon the crystalline, or first deposits, shells and fragments occasionally occur: these, therefore, have been termed *transition strata*; and it is imagined that the peopling of the ocean commenced about this period. The waters upon the earth began now more rapidly to subside, and finely divided particles, resulting from disintegration of the first formations, were its principal contents; these were deposited upon the transition rocks chiefly in horizontal layers. They abound in organic remains, and are termed by Werner *floetz*, or *secondary rocks.*

It is now conceived that the exposure of the *primitive*, *transition*, and *secondary* rocks to the agencies of wind and weather, and to the turbulent state of the remaining ocean, produced inequalities of surface, and that the water retreated into lowlands and valleys, where a further deposition took place, constituting clay, gravel, and other *alluvial* formations.

There are also certain substances which, instead of being found in regularly alternating layers over the earth, are met with in very limited and occasional patches. Rock-salt, coal, basalt, and some other bodies are of this character, and Werner has called them *subordinate* formations.

Lastly, subterraneous fires have sometimes given birth to peculiar and very limited products; and these are called *volcanic* rocks.

Such is Werner's account of the production of rocks, which he arranges under the terms *primitive, transition, secondary, alluvial, subordinate,* and *volcanic formations.* A number of nice distinctions and accurate minutiæ of description attend this theory, which we cannot notice in this bird's-eye view, and which do not affect the general conclusions.

If we examine the stratification of our globe, we shall doubtless find that certain substances do occur in a certain order of arrangement, and that they appear to have been successively deposited, one upon the other, in the manner Werner and his disciples would have us believe; but when we more minutely examine the structure of the earth's surface, and the relations of its different strata, so many incongruities are discovered, and so much is at variance with their leading doctrines, that we are obliged to give them up in favour of views more generally applicable.

2049. Dr. Hutton gives a very different account of the present order of things. Looking upon the face of nature, he observes every thing in a state of decay; and as she has obviously provided for the regeneration of animal and vegetable tribes, so the philosophic mind will descry, in this apparent destruction of the earth's surface, the real source of its renovation. The lofty mountains exposed to the action of the varying temperature of the atmosphere, and the waters of the clouds, are by slow degrees suffering constant diminution; their fragments are dislodged: masses are rolled into the valley, or carried by the rushing torrents into rivers, and thence transported to the sea. The lower and softer rocks are undergoing similar, but more rapid, destruction. The result of all this must be, the accumulation of much new matter in the ocean, which will be deposited in horizontal layers. Looking at the transition rocks of Werner, he perceives that, though not strictly crystalline, they appear made up of finely-divided matter, more or less indurated, and sometimes very hard in texture, and of a vitreous fracture; and that this hardening is most perceptible when in contact with the inferior rock, which often pervades them in veins, or appears to have broken up or luxated the superincumbent masses. According, then, to Dr. Hutton, the transition or secondary rocks of Werner were deposited at the bottom of the ocean in consequence of operations similar to those which are now active, and the primary rocks were formed beneath them by the action of subterraneous fires; their crystalline texture, their hardness, their shape, and fracture, and the alterations they have produced upon their neighbours, are the proofs of the correctness of these views. It is by the action of subterraneous fire, then, that rocks have been elevated, that strata have been hardened, and that those changes have resulted which an examination of the earth's surface unfolds. The production of soils, and of alluvial land, is considered as depending upon the same causes as those referred to in the other theory.

It will be observed that Hutton refers to fire as well as water for the production of our present rocks; the former consolidating, hardening and elevating, the latter collecting and depositing the strata. This system has been happily illustrated by many of the phænomena that occur among the mountains of Scotland, the birthplace of its inventor, and the seat of his speculations; it has been elucidated by the eloquent and philosophic pen of Mr. Playfair; and has received other advantages and aids, which the Wernerian theory has not enjoyed. But these circumstances must not be suffered to bias an impartial story; it is to facts we must attend, and upon them found our verdict.

Much as has been said upon the mischief of geological theories, which by some are represented as ingenious, though dangerous, fictions, no one can justly deny their importance and utility, as furnishing strong incitements to the labour of observation and experiment. He that has framed a theory is fond of searching for confirmations, and he proceeds with a real enthusiasm widely distinct from the cold accuracy of the mere accumulator of insulated facts. In all physical inquiries, theory and observation should go together, like mind and body, the one guiding and directing the other. It is quite true that the impartiality of an observer may often be affected by system; but upon this it has been justly remarked by Mr. Playfair, that it is a misfortune, against which the want of theory is no security. The partialities in favour of opinions are not more dangerous than the prejudices against them; for such is the spirit of system, and so naturally do all men's notions tend to reduce themselves into some regular form, that the very belief that there can be no theory, becomes a theory itself, and may have no inconsiderable sway over the mind of an observer. Besides, one man may have as much delight in pulling down, as another in building up, and may choose to display his dexterity in the one occupation as well as in the other. The want of theory, then, does not secure the candour of an observer, and may greatly diminish his skill. The discipline best calculated to promote both is a thorough knowledge of the methods of inductive investigation, an acquaintance with the history of physical discovery, and the study of those sciences in which the rules of philosophizing have been most successfully applied.

SECTION II. *Of the Succession of Strata incrusting the Globe, and of the Stratification of Britain in particular.—Of Granite, and other primary Rocks.*

2050. THE terms primitive and secondary rocks, employed in the description of Werner's theory, were introduced into geology by Lehman*, a correct and sensible writer of the middle of the last century. He considered the crust of the earth as presenting three distinct series of substances. The first, coeval with the world, he calls primitive, or primary, rocks. The second series are of more recent formation, and seem to have resulted from some great catastrophe, probably the deluge, tearing up, and modifying the former order of things ; and the third class owe their formation to partial or local revolutions, as indicated by their structure and situation.

---

* *Traités de Physique, d'Histoire Naturelle, de Minéralogie, et de Métallurgie.* Par J. G. Lehman: *traduits de l'Allemand.* Paris, 1759. " Les montagnes sont des élévations de la terre de différentes hauteurs, dont quelques-unes sont composées de parties dures, solides, et pierreuses ; d'autres sont composées seulement de parties terreuses ; quelques-unes ont été créés en même tems que la terre, d'autres ont été formées par des accidens, ou par des

2051. In taking a general view of the substances which incrust our globe, for of its nucleus we know nothing, we perceive certain distinctions of texture and disposition, which are at once curious and important. The rocks which I have elsewhere called primitive, or primary, are generally found in huge masses or blocks,

---

évènemens qui ont eu lieu, en différens tems."—Vol. iii. Sect. 3. " Il n'y a rien de plus naturel que de partager toutes les montagnes en trois classes. La première classe sera celle de montagnes qui ont été formées avec le monde. La seconde sera celle des montagnes qui ont été formées par unu révolution générale qui s'est fait sentir à tout le globe. La troisième classe, enfin, sera celle de montagnes qui doivent leur formation à des accidens particuliers, ou à des révolutions locales." " Les montagnes de la première classe sont élevées, dont quelques-unes se trouvent isolées dans des plaines ; mais qui, le plus ordinairement, suivent une longue chaine et traversent des parties considérables de la terre. Elles diffèrent des montagnes de la seconde classe : 1. Par leur élevation et par leur grandeur, qui surpassent celles de toutes les autres. 2. Par leur structure intérieure. 3. Par les substances minérales qui s'y trouvent."—*Ibid.*

These passages are sufficient to show the merits of Lehman as an original and acute observer, and have furnished subsequent geologists with the foundations of their arrangements.

not regularly stratified *, and affecting in their fractures and fissures, a vertical arrangement. Sometimes they are of a perfectly homogeneous texture, commonly hard and durable, and sometimes composed of two or three ingredients blended together; they are generally crystalline in their texture, and usually constitute the loftiest mountains. The transition series of rocks of the Wernerian school, or those which they hypothetically deem next in point of antiquity to the primitive, are less lofty than the former; they, in many instances, present a slaty texture; they seem to have been deposited in strata or layers, and these are seldom either vertical or horizontal, but variously inclined to the horizon. The secondary rocks, or the more recent series, are nearly, if not quite, horizontal in their position. In their texture they are soft, and consequently easy of decay, and they appear rather as mechanical deposits, than as chemical compounds which have resulted from fusion, crystallization, or solution. The wood-cut at the head of this Chapter may serve to give some idea of the relative heights and aspects of these three series of rocks.

These different series are tolerably regularly arranged in regard to each other. The primary rocks form the bases upon which the others rest; the transition are immediately recumbent upon these; and these are succeeded by the varieties of secondary rocks, and by their detritus constituting alluvial matter and soils.

2052. In selecting illustrations from nature of the different geological phænomena that come before us, I

---

* To this distinctive character there are, however, numerous exceptions; gneiss, mica, slate, quartz, rock, and clay slate, exhibiting a distinctly stratified arrangement.

shall in all cases prefer reference to our own country; and I presume that it would, on the whole, be difficult to select a better spot for the study of geology than Great Britain. We have every variety of rock presented under its various aspects; and, though in foreign climes nature may have more liberally dispersed the sublime, she has no where more instructively or delicately diversified the earth's surface than in the small space allotted to the British isles.

A section of the south of England, from the coast of Cornwall, for instance, in the west, to London in the east, will furnish a good exhibition of the phænomena of stratification to which I have just alluded. It will begin at the Land's-End, with primitive rocks, massive and amorphous. Upon this rest several species of transition rocks, especially slates of different kinds, having various inclinations; and these are succeeded by secondary strata, deviating more and more from the vertical, and acquiring the horizontal position; and ultimately we attain the alluvial matter upon which the metropolis stands. It is principally clay, and has once perhaps formed the mud at the bottom of a salt-water lake*.

Proceeding from London northwards, towards the Scotch border, the order of stratification is reversed; and traversing a highly interesting series of secondary rocks, we arrive in Cumberland at some of the primitive series. The whole arrangement is such as to include the highest and oldest rocks upon the west side of England, forming an interrupted chain extending from the Land's-End, in Cornwall, to Cumberland, and thence to the northern extremity of Scotland. So that the length of Great Britain, and its general shape, appear in a considerable degree dependant upon this chain of mountainous land, and upon two lower ridges, which extend in one direction from Devonshire, through Dorsetshire, Hampshire, and Sussex, into Kent; and in another, nearly from the same point, to the east of Yorkshire.

---

* Mr. Greenough's valuable Geological Map of England and Wales, and Mr. Smith's Geological County Maps, will be found very useful to the student; to whom I also recommend Mr. W. Phillips' *Selection of Facts*, &c., as an excellent abridgment of the important materials contained in the *Geological Transactions*.

The western ridge is broken in upon in several places by plains and rivers, giving rise to so many chasms in the great chain.

In the Descriptive Catalogue of the Geological Specimens in the Royal Institution *, an attempt has been made to follow the natural succession of strata in Britain, and to show their successive alternations; and I trust that it will prove serviceable in connecting the following observations with their respective illustrative districts of our island.

2053. Of the primitive rocks †, one of the most abundant in nature, and the most useful in its applications, is GRANITE, so called from its appearing to be made up of a number of distinct grains or particles. Its essential component parts are *quartz*, *feldspar*, and *mica*.

2054. *Quartz* is the substance commonly called *rock crystal*, and has already been described (1320). It is sometimes met with in mountain masses, which usually present a conical appearance. The quartz is milk white, and of a more or less granular texture. The Sugar-Loaf Mountains near Dublin, the Paps of Jura in Argyleshire, and some of the mountains of Sutherland and Caithness, present instances of this formation, which is stratified in the island of Jura [*]..

---

* *A Descriptive Catalogue of the British Specimens, deposited in the Geological Collection of the Royal Institution.* Longman & Co., 1816.

† In selecting specimens of rocks and strata for the geological cabinet, we should endeavour to show their recent fracture, as well as their weather-worn surface, which is generally easily attainable.

2055. *Feldspar*, the next constituent of granite, is a compound body, of which silica and alumina are predominant ingredients; it generally contains a little lime and potassa, and is often coloured by minute portions of oxide of iron[†]. Sometimes it is found crystallized, when it assumes the form of four and six-sided prisms, bevilled on the extremities; its usual colours are red, white, and grey. It is softer than quartz, but harder than glass, and is characteristically marked by fusibility before the blowpipe.

Feldspar is a very important ingredient in many kinds of pottery; and the substance used by the Chinese, under the name of *petuntz*, is probably of a similar nature. The decomposing feldspar of Cornwall is abun-

---

[*] *Geological Transactions*, ii. 450.

[†] In a fine specimen of pale flesh-red feldspar, from the Alps, crystallized in the form of the oblique four-sided prism, I found the following constituent parts:

Silica	68.00
Alumina	20.00
Potassa	8.30
Lime	2.00
Oxide of iron	0.50
	99.00
Loss	1.
	100.00

dantly employed in the English porcelain manufactories, and, as it contains no iron, it retains its perfect whiteness. According to Mr. Wedgwood, it consists of

60 alumine
20 silex
20 moisture and loss.

There are some beautiful varieties of feldspar employed in ornamental jewellery, such as the *green* and *blue* or *Amazon-stone*, of Siberia and America; the *foliated*, *pearly*, or *resplendent feldspar*, called *adularia* and *moon-stone*; and the feldspar of the island of St. Paul, upon the coast of Labrador, distinguished by the property of reflecting very beautiful colours when the light falls upon it in certain directions. Feldspar is an important component of several other rocks besides granite.

2056. *Mica*, the third and last of the essential ingredients of granite, is a well-marked compound mineral, consisting principally of alumina and silica, with a little magnesia and oxide of iron. Its texture is lamellar, and it is easily split into thin, flexible, elastic, and transparent plates. It is so soft as readily to yield to the nail; it is sometimes met with crystallized in four and six-sided plates and prisms. Its usual colours are shades of brown and grey; sometimes it is red, and sometimes black. In some parts of Siberia mica is copiously quarried, and is employed as a substitute for glass in windows and lanterns. It has been thus used in Russian ships of war, where it has the advantage of not being shattered, like glass, by the discharge of artillery. The extreme tenuity of the plates into which it may be divided, and their elasticity, renders it very useful for the enclosure of objects to be submitted to microscopic inspection.

2057. Such are the characters of the components of granite; in some specimens of which they may be distinctly traced and separated from each other, but sometimes the particles are so small as to produce a compound, which to the unaided eye will seem almost homogeneous. We have, therefore, *fine* and *coarse-grained granite*. The former is abundant in Scotland, the latter in Devonshire and Cornwall. Indeed, the Cornish granite is remarkable for the well-defined and large crystals of feldspar which it contains, and which may be seen in many parts of London, where this rock has been used for paving, and where the crystals of white feldspar have become evident in the mass, from the constant attrition to which it has been subjected. It is of this stone that the Strand Bridge is mainly constructed. The colour of granite is principally dependant upon that of the feldspar it contains, though a dark mica will often give it a gloomy hue. It is commonly grey or reddish.

2058. There are two rocks very closely allied to granite, and usually associated with it; I mean slaty granite, or GNEISS, composed of precisely the same materials as granite, but slaty in its fracture, owing to the comparatively large quantity of mica it contains; and the other rock is a compound of mica and quartz; it has a slaty texture, and also derives its leading characters from the large quantity of mica it contains; it is called MICA SLATE.

2059. On the origin of granite geologists widely differ. As it constitutes the basis upon which all other rocks appear to lie, Werner has regarded it as the first formation of that chaotic rock-depositing fluid, in which he imagines the earth once to have been enveloped. But many peculiarities of granite have been adduced by Dr. Hutton, as contrary to such an opinion. If we examine a granitic district in nature, we shall observe, in regard to it, two leading phænomena. The one is, that veins of granite frequently shoot from the great mass into the superincumbent strata. The other, that the bodies lying upon granite, especially if they be stratified, either bear evidence of having been broken up, dislocated, and penetrated by the granite, whilst in a fluid state; or they seem as if gradually elevated by some power which has thrown the granite up from below. So that, upon this view of the subject, the date of granite, as far as concerns its present position, is posterior to that of the strata that rest upon it. They were first deposited, and the granite then erupted from beneath, and elevated the other strata, throwing them out of the horizontal, and giving them various inclinations to the horizon, or sometimes a vertical position. The Brocken Mountain in the Hartz Forest in Germany, St. Michael's Mount in Cornwall, and the granitic district at Aviemore in the Scotch Highlands, will furnish illustrations of this subject. The first I select as being, at the same time, one of the favourite proofs with the Wernerians of their master's theory, while the Huttonians may regard it no less favourable to the truth of their views.

Of this mountain the peak is granite, and upon it are regular layers of other rocks, the dip or inclination of which is regulated by the surface of the central granite. In inspecting a section of the Hartz mountain, it will, I think, hardly be denied, that the appearance is rather in favour of the elevation of the strata, by the eruption of the granite, than of the original deposition of the granitic nucleus, and the successive subsidence of the other strata upon it.

At St. Michael's Mount, in Cornwall, a schistose, or slaty, rock, is invaded by a mass of granite from beneath; veins of the latter penetrate the former, which is hardened, and broken, apparently by the force with which the granite has been protruded. Indeed, the whole granite district of the west of England, beginning at Dartmoor, in Devonshire, and extending to the Land's End, in Cornwall, presents appearances, which are no way so well accounted for as upon that hypothesis which considers the granite to have been thrown up from below in a fused state, and to have forced its way through the superincumbent strata. There are four granitic summits in the promontory of Cornwall, all probably connected with each other, and with that at Dartmoor: and the surrounding country is principally clay slate, which every where inclines to the granite, in the same manner as the strata of the Brocken, in the Hartz Forest.

In the hill at Aviemore, to which I have alluded, veins of granite are seen penetrating the slaty rock in all directions; and upon the weather-worn side, facing the north-east, a large vein of granite may be perceived, widest at bottom, running nearly perpendicular, and enlarging into a mass, or stratum, of granite, between the schistose layers.

Such, then, is the appearance of granite, and such the arguments of the Huttonian geologist concerning its origin. I have mentioned that the superincumbent rocks are frequently penetrated by granite veins, and it is obvious that every vein must be of a date posterior to that of the body which contains it; and further, as the veins are often observed to proceed from the main body of the granite, into the superincumbent strata, it may be argued, *that the mass of granite, and the veins proceeding from it, are coeval, and both of later formation than the immediately superincumbent strata.*

Veins of granite, however, are frequently discovered, which cannot be traced to any original mass, or mountain; they seem to be insulated, as it were, among other strata. This is the case at Portsoy, and in Glentilt; and in some of the Western Isles of Scotland, especially Tiree and Coll; and is also observed in many parts of Cornwall. Dr. Hutton, from collateral evidence, conceives that these are always united to some granitic mass, though too deep, or at too great distance, to be traced and discovered.

It may now be asked, how the pupil of Werner accounts for phænomena of this kind? I have already said that he regards granite as having been deposited before all other rocks, though its irregularity and its general want of stratification are decided objections to such an idea, and that the other substances were precipitated upon it in the order we find them. In these strata, cracks and fissures occurred, and a new deposition of granite took place from the chaotic fluid, confined to the said cracks and fissures, and producing the appearance of granitic veins; and the hardening of the neighbouring rocks, referred by the Huttonians to the heat of the injected granite, is accounted for by the infiltration of the aqueous solution, which has, as it were, lapidified the softer materials. Now, though we may imagine granite to have been in igneous fusion, we cannot easily conceive it susceptible of aqueous solution; and if so dissolved, why should its second deposition have been confined to the cracks and fissures; Why should it not have formed a new stratum? With these facts before us, it is useless to enter into further comments, and we can only embrace that hypothesis, (for, after all, it is but hypothesis,) which appears best supported by evidence derived from actual observation*.

2060. The aspect of a granite district in nature is subject to variation; it, however, exhibits traits sufficiently peculiar, which are readily recognised by the traveller in his approach to it.

In Cornwall, and in some parts of Ireland, especially in the county of Donegal, the granitic rocks are marked by the bold and abrupt precipices which they present to the attacks of the ocean; and by the barren and dreary aspect of the inland plains, that seem like fields, in which blocks of the stone have been torn from their beds, and indiscriminately scattered over the moss-grown surface. The elevation of these districts is not considerable, the granite is coarse grained, and splits into immense blocks, separated from each other by natural seams, and appearing like the ruins of edifices constructed by a giant race. In other cases, granite forms irregular and broken peaks, of prodigious elevation, and does not split into the blocks and masses just alluded to. This is the case in the Alps and Pyrenees, in the highest Scotch mountains, in the Hartz, and in the Tyrol.

---

* Some have regarded granite as a congeries of crystals of mica, feldspar, and quartz, accidentally blended and united; the inspection, however, of the rock, clearly proves that all its materials have been together in fusion; for we find in some granites the quartz impressed by the crystals of feldspar, and in others the feldspar receives impression from the quartz. Dr. Hutton has looked upon this as demonstrating the igneous fusion of granite, for, (says Mr. Playfair,) "had the materials been dissolved in water, one kind of crystal ought not to impress another, but each enjoy its own peculiar shape." This, however, I do not hold to be sound argument.

In Asia and Africa granite constitutes the Uralian, Altaian, and Himálayán chains, and the Atlas mountains; and in South America, the lofty ranges of Cordilleras are chiefly of a similar description. The wood-cut at the head of this section shows the appearance of the alpine and of the massive granite. The sketch is taken from that of Mont Blanc, and of the Land's-End, in Cornwall.

2061. Some kinds of granite are prone to decomposition, crumbling down into a fine clay containing siliceous particles: this probably arises from a peculiarity of the feldspar, afterwards to be noticed. In general, granite is the most durable of nature's productions, and long resists the destroying hand of time; as a building material, therefore, granite is almost unrivalled: and, though in common cases its extreme hardness is against its employment, its use should be enjoined for public edifices. Dublin furnishes some noble examples of buildings constructed of granite, which is there procured in the immediate vicinity of the city, and of a very beautiful kind.

In Wales there is very little granite; in the north of Scotland it is abundant; and in England it occurs in Cornwall, Devon, Westmoreland, and Cumberland. It is also met with in smaller quantities in Worcestershire, at the Malvern Hills; and in Leicestershire, in Charnwood Forest.

2062. Although granite probably exists in great abundance below the earth's surface, the quantity visible above ground is comparatively small, perhaps not amounting to a hundredth part of the other primitive and transition rocks. In some parts of Scotland the granite superficies, however, is very considerable, and much exceeds the limits assigned to it by Dr. Hutton. Upon this subject a very acrimonious controversy arose between Dr. Hutton and Mr. Kirwan; the general statements, however, of the former, in this and other cases, commonly make much nearer approach to truth than those of the latter; but as human reason is not infallible, he who always contradicts must sometimes be right, and thus the mere cavilling disputant may occasionally discover the errors of the slow and cautious observer of nature.

2063. To the class of massive unstratified rocks belongs PORPHYRY, a substance which is ranked by Werner among the primitive formations. Its essential constituent is feldspar; and genuine porphyry may be defined as massive feldspar, containing embedded crystals of the same substance. Any rock including distinct crystals of feldspar, is called *porphyritic*, as *porphyritic granite*, &c. The colour of porphyry, which is usually reddish, brown, and green, is principally derived from the base, or paste including the crystals. The common aspect of porphyry is that of blocks and masses, not very unlike some of the varieties of granite, but its fragments are generally smaller, and are in a more decaying condition. Porphyry is an extremely durable material for architectural purposes, and as such was highly esteemed among the nations of antiquity. It is met with in many parts of Britain: and in the north, the porphyry districts are of singular grandeur, as at the base of Ben-Cruachan, on the banks of the Awe; and amidst the precipices of Ben-Nevis, the highest of the British mountains.

The British porphyries are many of them of great beauty, and might well be substituted for all ornamental purposes, for the more rare and expensive foreign varieties.

2064. Granitic rocks frequently contain a large proportion of *hornblende*, a mineral of a greenish black colour, which sometimes forms prismatic crystals; it consists of silica and alumina, with magnesia; and appears to derive its colour from oxide of iron, of which it contains from 20 to 30 *per cent.* Hornblende sometimes passes into mica; and if the component parts of the two bodies be compared by analysis, the principal difference will often be found to consist in the excess of iron in the former.

These aggregates are termed SYENITES, or *syenitic* rocks, and are of various hues, according as one or other of the constituents predominates. Sometimes the place of the quartz is wholly occupied by hornblende, and the rock is principally an aggregate of feldspar and hornblende. The term *syenite* is derived from Syene, in Upper Egypt, where this rock is plentiful, and was used for architectural purposes by the Egyptian and Roman sculptors. The aspect of syenitic rocks is allied to that of granite and porphyry. They may be observed rising from the slaty district of St. David's, in Pembrokeshire; and in Cumberland, near Wastdale and Buttermere. A beautiful syenite is noticed by Mr. Bakewell, as occurring in Leicestershire, at Markfield-Knowle, a hill on Charnwood Forest. Syenite very often contains magnetic oxide of iron.

2065. Another substance belonging to the class of rocks we are now describing, is SERPENTINE; its appearance is singularly picturesque and beautiful; and it forms a delightful contrast to the sublimity of granitic districts. Serpentine has its name from the variety of tints which it exhibits, such as bright red, green, brown, yellow, and their various shades, and it often is prettily traversed by veins of a soft substance, to which the term *steatite* or *soapstone* has been given (698)*.

Some of the varieties of serpentine admit of a tolerable polish, and such are very desirable for many ornamental purposes.

Serpentine is seen in Cornwall in characteristic beauty, forming part of the Lizard promontory on the southern coast of the county, where its general aspect is shown in the following sketch. It appears in variously shaped and coloured blocks and masses; it forms natural arches, columns, and caves; and the district is of very singular interest from many concomitant circumstances, especially from the blocks of porphyry upon which the serpentine is incumbent, and the veins of granite associating with those of steatite, which pervade it.

---

* Serpentine has been repeatedly analyzed; but the results are very discordant; no doubt owing to the indeterminate nature of the rock. See JAMESON'S *Mineralogy*, 2d edit., Vol. i., p. 509. Its principal constituents appear to be silica, magnesia, oxide of iron, and a little carbonate of lime. See the analyses of *Serpentine*, given above (1394).

Serpentine is met with also in the Isle of Anglesea, upon the northern coast near the celebrated Parys Mine. Some of the serpentine of this district is of more brilliant colours, more hard and translucent than the ordinary serpentine; it belongs to the species called by mineralogists *noble serpentine*; the same rock occurs at Portsoy, on the Murray Frith in Banffshire, where it is associated with granite.

The composition of serpentine, as relates to its proximate components, has been variously described. It is generally so fine grained as to appear of an uniform texture; but in Cornwall a coarsely aggregated rock, consisting of *feldspar*, *talc*, and *schiller spar*, may be traced passing into the fine-grained serpentine. I have already alluded to the nature of feldspar. *Talc* is a body somewhat resembling mica in appearance, but the plates into which it is divisible are not elastic. Its usual colours are various shades of green. It consists of nearly equal parts of silica and magnesia, with a little lime; not more than six *per cent.* It is met with in small tabular crystals.

Schiller stone, or *schiller spar*, is a term from the Germans, implying glistening or changeable spar: it is one of the varieties of *diallage* of the French authors; it is a silico-ferruginous fossil, containing

44 silex
24 iron
18 alumina
12 magnesia.

Its colour is dark green: its usual lustre is semi-metallic, varying according to its position in regard to incident light.

Steatite is a substance of different tints of grey and green, and from its very singular unctuous feel, has been called *soap-stone*. It is somewhat abundant in the serpentine of Cornwall, one of the masses of which is called the *soapy rock*; it is here carefully collected for the porcelain works of Worcester and Swansea, in which it forms a very important ingredient. It also occurs in the serpentine of Banff. According to Klaproth, Cornish steatite consists of

Silica	45.00
Magnesia	24.75
Alumina	9.25
Iron	1.00
Potassa	0.75
Water and loss	18.00
	98.75[*]

2066. Marble (643) is the last of the rocks belonging to the class I am now describing. It is also very abundant in the secondary rocks, but its characters are there different. Among primary rocks, marble is associated with mica slate, gneiss, serpentine, and quartz rock, and it differs from marble belonging to other rocks, in its granularly foliated texture and in the absence of organic remains. The most esteemed varieties are perfectly white and free from veins; somewhat translucent, and susceptible of a good polish. These marbles are imported for ornamental purposes, especially for those of the sculptor. Nearly all the sublime works of the Grecian artists were sculptured in the marble from the isle of Paros in the Archipelago, and from the Pentelic mountain near Athens; but the marble of Carrara is now in highest estimation, and is almost exclusively used by the European sculptors of the present day. Of the coloured varieties, that of the isle of Tiree is extremely beautiful; it is of a pale red, spotted with green hornblende. Marble is found in several parts of Scotland, and in some places of characteristic beauty, and alternating within small limits, with other rocks. Dr. Mac Culloch, in his *Sketch of the Mineralogy of Sky*[*], has described several beautiful varieties found in that island, and has adverted to the œconomical uses to which they are applicable. In Inverary park primary marble may be seen in contact with mica slate and porphyry. Serpentine and marble are sometimes blended together, and they then form a valuable compound for ornamental purposes, which has been called *Verd Antique*. In the serpentine of Anglesea, patches of marble are found which much enhance its beauty.

---

[*] Vide Klaproth's *Beiträge*, V. Band, S. 24.

A very remarkable marble quarry is that of Icolmkil, or Iona. Gneiss rocks constitute the leading feature of this island, but at the south-west point is a bed of marble, about 40 feet wide, bounded by vertical walls of hornblende rocks[†]. Near it is a mass of hornstone, and above the whole protrudes an immense vein of gra-

---

[*] *Geological Transactions*, iii. p. 1.

[†] The marble is of the species called *dolomite* (698), distinguished from the true primary marble or granular lime-stone, by the tardy effervescence excited by pouring muriatic acid upon it, and by its containing magnesia; it is also finer grained, and its fracture more splintery, than that of common marble. The dolomite of Iona yielded to Mr. Tennant,

Carbonic acid	48.82
Lime	31.12
Magnesia	17.06
Insoluble matter	4.00

Phil. Trans. 1799.

The dolomite of the Apennines yielded to Klaproth,

Carbonate of lime	65
Carbonate of magnesia	35

Beiträge, B. 4, S. 215.

nite, surrounded by the marble, but from which it has been loosened, so as just to admit a person to pass between the two walls. That they have once been in contact, is proved by the granitic protuberances having correspondent indentations in the marble, and *vice versâ*.

2067. We have now considered a highly important series of rocks, and have enumerated their characters as insulated individuals. As a class they present analogies which distinguish them from their superincumbent neighbours, and give them the stamp of a peculiar and distinct formation, either formed before organic beings, or under circumstances which have destroyed such remains.

In these rocks we seldom observe any regular stratification; they are mostly constituted of amorphous, irregular, and various masses, and present no appearances of having been deposited from water. They are crystalline aggregates; and they are deeper in their situation than other rocks, which always appear incumbent upon them, and often elevated or heaved, as it were, by their operation.

They often break through the beds, or layers, that cover them, and rise to a very great elevation, forming the summits and peaks of the loftiest mountains. In England they are comparatively rare; in Cornwall there is abundance of granite, but it rises to no great height. Granite and its associates are found in Cumberland, but they are sparingly scattered over the county; and the romantic and picturesque aspect of the hills is chiefly derived from other species of rocks. In Wales, the primary rocks are uncommon, and I know of no granite; but there is a portion to be found in the centre of Anglesea, near Gwindy, where its associations merit notice.

In Scotland, the districts composed of primitive rocks, and presenting their various aspects, junctions, and transitions, are full of grandeur and interest. Travelling northwards from Edinburgh, we enter upon mica slate at one of the Highland passes, and, crossing the Grampians, find their principal summits of the same materials. From Loch-Tay to Killin, the same rocks continue, with beds of limestone. Ben-More is a mica slate rock, of exceeding grandeur; it rises to about 4000 feet above the sea's level, and is thickly intersected with quartz veins. Ben-Lawers, to the North of Loch-Tay, is of similar composition; it is chiefly gneiss, associated with mica slate and quartz; and the same substances are found at Crag-Caillach, and Schehallion, and contribute to the magnificence of the celebrated pass of Killikrankie, between Dunkeld and Blair in Athol.

I have thus represented the highest mountains in Britain as composed of granite and its associates; but these are mere trifling protuberances upon the earth's face, when compared with the exceeding heights of the Alpine chain, or the yet more elevated mountains of South America, and of Asia, which consist of the same materials. Ben-Nevis, the loftiest of the British mountains, is situated in the south of Inverness-shire, and is 4370 feet high. Cairngorm, in the same county, is 4050 feet high. Mont Blanc, in Switzerland, has its peak elevated 15,600 feet above the level of the sea; it is the highest mountain of Europe; Chimboraso, the highest summit of the Andes, is 20,280 feet above the sea's level; many of the peaks of the Himáláyá chain are as high, and the loftiest appears to exceed 25,000 feet *.

The reason why these excessive elevations present nothing but primitive rocks, and especially granite, (excepting, indeed, where they are volcanic) may not at first appear quite obvious, for in the low lands the primitive are generally covered by secondary strata, which were also once probably incumbent upon their loftiest summits. It is likely that the destructive agencies of the elements have been so powerfully exerted in these elevated and unprotected regions, that the secondary rocks have yielded to their unceasing attacks, and have been carried towards the valleys by the rills and torrents, while granite and its durable accompaniments have more obstinately opposed the inroads of such resistless assailants.

2068. At the same time, however, it will seem probable that the granitic mountains have themselves suffered tremendous degradation, and that at a former period their summits were beyond their present elevation. All this will appear more clear when the general characters of mountain chains, and the phænomena of their decay, are taken into the account. But several circumstances present themselves to the most superficial observer, which, in a language that it is impossible to misinterpret, announce the influence of destructive agents upon these apparently invulnerable materials. Prodigious masses of granite are often found among the secondary strata that form the valleys under primary mountain chains; they are insulated and unconnected

---

* See an article on this subject in the sixth Volume of the *Quarterly Journal of Science and the Arts*, p. 55.

with any general mass of the same material; and the more distant they are from the granite range, the more they are rounded and smoothened upon the surface. Of this description are the boulders, or blocks of granite, observed by Saussure upon the east side of the lake of Geneva. One of these, called *Pierre dé Gouté*, is ten feet high, with an horizontal section of 15 feet by 20. In the valley of Chamouny, several similar blocks have fallen from the Aiguilles. Some of these have been transported between 30 and 40 miles, and as several mountains and valleys are now interposed, their transportation must have taken place at a very remote date*.

In the glen which separates the Great from the Little Saleve, there are many granite boulder stones strewed over a calcareous plain; and of these several are supported upon a short pillar of limestone, resulting from the protection afforded to the calcareous rocks by the harder boulder, so that the height of the column becomes a measure of the wearing away of the surrounding country. This appearance has induced Saussure to assert, that these stones are now in the very situation where they were left by the great aqueous torrent, or debacle, which tore them from their original bed, and brought them down from the high Alps; a conclusion, however, as Mr. Playfair has remarked, not altogether warranted by the fact. In some of the recesses of the Jura there are large, and somewhat angular, blocks of granite, which have evidently been deposited in their present situations at very remote periods, the surrounding and impending heights being composed of limestone rocks, which form an amphitheatre round the present valleys. In the neighbourhood of Neufchatel, too, there is an enormous insulated mass of granite: it is as large as the celebrated foundation of the statue of Peter the Great, erected at Petersburgh by Catherine II., which is composed of a boulder, or detached block of granite, found in a bay of the Gulf of Finland, whence it was transported to the capital; its length was 42 feet, its breadth 27 feet, its height 21 feet*.

---

* See Dr. KIDD's *Geological Essay*, Chapter xviii., which contains an account of the most remarkable boulders.

In the Isle of Arran, an immense block of granite is found upon the shore, not only three miles from the nearest granite rock, but having also a bay of the sea intervening; and several similar instances might be adduced, proving the great ravages that have been committed upon even so hard and unyielding a body as granite. We shall not, then, be surprised that the same agents, acting upon softer materials, have made more successful depredations; and have, in many instances, completely denuded those granitic surfaces, which were once clothed by secondary strata.

2069. In Cornwall, granite is sometimes of very rapid decomposition, and the streams which traverse these districts deposit a finely-divided earthy matter, resulting principally from the feldspar, and much used in the potteries. Carglaise tin mine is situated in a decomposing granite of this kind, and presents a spectacle highly worthy the attention of the curious. The mine is a vast chasm in the granite rocks, and exposed to the day. The tin ore and shorl rock traverse it in abundant veins, and the surrounding peaks strongly remind the beholder of a miniature representation, or model of the Alps. Possibly the rapid decay of the granite here depends upon the quantity of alcali contained in its feldspar.

---

* See the *Relation*, par le Comte Marin Carburi de Ceffalonie, &c. Paris, 1777.

Dr. Mac Culloch, in a dissertation on the granite Tors of Cornwall, published in the *Geological Transactions*, has made some interesting remarks upon the peculiarities which they present, and which have given rise to much idle and ignorant speculation. A very remarkable Tor is the *Cheese-wring*, upon an eminence near Liskeard. It is a cairn consisting of five stones, of which the upper ones are larger than and overhang the lower, the whole pile being 15 feet high. The stones of which it consists are yielding to the weather most rapidly at their angles and edges; they are thus becoming rounded, and approaching that tottering state which will soon hurry them down the precipice to their former companions in the plains below.

This tendency of square blocks of stone to become spherical, independent of friction, is productive, in other cases, of very curious consequences, and has often been considered as demonstrating the agency of streams or currents, by which the masses have been transported from distant regions. The present Tor has, by some antiquarians, been considered as a druidical statue of Saturn. The same cause appears to have produced the celebrated Logging-stone.

2070. Before we quit the subject of primary rocks, it will be right to mention a district of Britain, which, for grandeur of scenery and geological interest, can, I think, scarcely be surpassed. I allude to the country between the eastern extremity of Loch-Ness and Fort-George, and especially to the rocks over which the river Fyers pursues its turbulent and winding course.

These are seen in characteristic grandeur in the neighbourhood of the small inn called the General's-hut, and the scenery becomes more and more impressive and interesting until we arrive at the celebrated falls of the river. I should call the rock a *granitic breccia*, or *conglomerate;* it appears made up of numerous angular fragments of granitic materials, held together by a siliceous cement, and the aggregate is of extreme hardness and durability; masses resembling jasper and agate may also be observed in it. Dr. Garnet compares the cement, or basis of the rock, to a *lava* of a reddish hue; and a common observer would consider the whole as fragments of granite which had been united by semi-fusion, or softened and glued together, as it were, in the fire. The general aspect of the surrounding scenery is such as to impress the mind with the idea of some vast convulsion of nature having torn the rocks asunder, and shattered them into gigantic fragments; rugged crags and abrupt precipices present themselves on all sides, and the river rushes with tremendous impetuosity through deep and obstructed chasms. A rude bridge is thrown over the upper fall, whence the spectator beholds the waters of the Fyers, at the distance of 200 feet beneath him, rushing into a cavity of 70 feet in depth, whence they again emerge in perfect stillness, and, running over an uneven and fragmented channel, approach the lower or grand fall. Here the waters, previously pent up and exasperated, suddenly discharge all their violence, and are lost in a deep abyss. The depth of the chasm in which the river flows is 400 feet, and it bursts forth in an unbroken stream, constituting a fall of 212 feet perpendicular height. The rugged irregularities of this district, the fragments that lie thickly strewed upon the sides of its mountains, the caverns that abound in its rocks, and the perpendicular precipice of the great cascade, considered conjointly with the peculiar texture and composition of the materials that form it, present many objects worthy the attention of the geologist, and may be regarded as recording some great natural convulsion, which has not only broken up and reunited certain primary rocks, but has again disturbed their tranquillity, and thrown them into the stupendous confusion they now exhibit.

Section III. *Of Stratified Rocks, and of the Transition and Secondary Formations of Werner.—Rock-salt, Coal, Alluvial Matters, Basalt.*

2071. We now descend from the primitive, to the *transition rocks* of Werner ; these are more particularly the *stratified rocks* of the Huttonian geologists, and they are distinguished by several well-marked characters from the unstratified and primary rocks.

One leading and general circumstance may be observed in regard to them, which is, that they never attain the great elevation of the primary bodies ; this has been elsewhere referred to the comparative readiness with which they yield to the assaults of decomposition and disintegration.

The highest known mountains in the world are those of Thibet, constituting the Himáláyán chain. They are alluded to by Col. Kirkpatrick, in his *History of*

Huttonian interpretation. It is probable, then, that the materials of the transition rocks, or, as I would rather put it, of those secondary and stratified rocks which are immediately incumbent upon the unstratified primitive rocks, are derived from the destruction of a former order of things; that they have been delivered into the ocean by the rivers, that they have covered the bottom of the sea, and have been hardened, elevated, and traversed by the eruption of granitic and other substances belonging to that class, from the bowels of the earth.

2073. The next peculiarity of the secondary rocks that presents itself, is their containing fragments, pebbles, and organic remains; whence cosmogonists have framed sundry conclusions concerning the particular period of their formation, which, it will be unwise and useless here to discuss. At the same time, the presence of bodies which once belonged to the organized kingdoms, but which, although still retaining their original forms, are completely fossilized, furnishes us with many interesting conclusions, and holds out to the inquisitive unfailing matter of useful discussion. In the oldest secondary rocks fragments are often found, and rounded pebbles, whence we learn their origin from former rocks. Upon these, beds occur which contain remains of shells, corals, and fish, all of marine origin, and oftentimes the races are extinct. Approaching the newer rocks, relics of quadrupeds, now no longer known, are observed; and, following the deposition of strata, we ultimately arrive at remains of lizards, crocodiles, elephants, deer, and some other animals; and we occasionally discover districts containing land and sea-shells in alternating layers.

I merely make allusion to these facts, to show how curious and new is the field of inquiry, which modern geology has opened. It has taught us that whole races of animals have been swept from the earth's surface; that not only species, but likewise genera, have become extinct; that fresh water and dry land existed before the formation of many of our secondary strata; that oviparous quadrupeds began to exist along with fish, nearly at the commencement of the secondary formations; that mammiferous sea animals are of more ancient formation than land animals; that a few of those now known, existed towards the termination of secondary formations, but that by far the greater number are of later date, and probably contemporary with the present order of the earth's surface, for their bones are only discovered in very recent depositions, and are in a state of inferior preservation to those of more ancient date; and, lastly, it is to be observed that no fossil human remains have yet been found.

Such are some of the topics which this part of geology presents for consideration, and which show us that the earth is indeed "as a book, in which men may read strange matters." Though the existence of fossil remains must have been noticed from the earliest ages, the philosophical discussions to which they have given rise are of very modern date, and the merit of fixing the geologist's attention upon them, as recording certain revolutions of the globe, belongs chiefly to Cuvier.

Further, to promote attention to the nature and arrangement of the secondary rocks, it may be suggested that they are the chief repositories of metallic substances; and that, by their decomposition and decay they furnish the principal materials of the soil in which the vegetable has its habitation, and consequently upon which the existence of animals ultimately depends.

2074. Of the secondary rocks, CLAY-SLATE may be first noticed; it is extremely abundant, and generally immediately incumbent upon the primary series. It is often micaceous near the junction, and we frequently observe it fragmented, and penetrated by quartz, or feldspar, or mica, or by granite itself. Before the blowpipe, it fuses into a black mass; its usual colours are various shades of grey, and it is generally so soft as to yield to the nail. Siliceous and argillaceous earths, and oxide of iron, with a little lime and magnesia, are its principal ingredients *. The varieties of slate are applied to various useful purposes; that which is easily separable into thin plates, compact, sonorous, and not injured by the application of a moderate heat, is employed for roofing houses. London is chiefly supplied from Bangor, in Caernarvonshire; and from the neighbourhood of Kendal, in Westmoreland: there are also very large quarries at Easdale, in Argyleshire; according to Mr. Jameson, five millions of slates are there annually manufactured, which gives employment to 300 men.

---

* I obtained, as the results of the analysis of a specimen from Luss, near Dumbarton, the following component parts:

Silica	48
Alumina	28
Magnesia	5
Lime	2,5
Oxide of iron	10
Loss	6.5
	100.0

There are several slate quarries of note in Dumbartonshire; one ought particularly to be mentioned, at Luss; it is of geological interest, and commands a captivating view of the lake, and the neighbouring mountains. Here the clay-slate rests upon mica slate; the former is of a purplish tint, penetrated by veins of pink carbonate of lime, and of quartz; the latter is very remarkably contorted.

2075. Other varieties of clay-slate are used for writing-slates, slate-pencil, *&c.*; and where slate is very abundant, we observe it employed for monumental tablets, pavements, and walls. Crystals of iron pyrites, and some other extraneous bodies are not rare in slate; these generally render it unfit for the applications I have alluded to. Slate often contains fragments of other rocks, embedded masses, and nodules of various kinds, frequently pebbles, and occasionally a few impressions of shells; it also often derives a green colour from the presence of a mineral called *chlorite*, consisting of oxide of iron united to siliceous and aluminous earths. The slates containing embedded matters are called *grauwacke-slates*, or, when of a less slaty fracture, simply GRAUWACKE, a substance which is abundant in this country.

2076. The slate district of England is of considerable extent, and neither wants sublimity nor grandeur; it follows the great primary chain which I before alluded to, as running north and south upon the west side of England; in Cornwall the slate is seen immediately incumbent upon granite, and the slaty districts form very beautiful scenery upon many parts of the coast. The term *killas* has been applied to it by the miners. Nothing, I think, can exceed the scenery about Looe, Fowey, and the country between it and Falmouth, and upon the north coast Tintagell is yet more remarkable.

There is some grauwacke in many parts of Cornwall. The best marked specimens I have seen, are from Mawnan, near Falmouth, where it alternates with clay slate.

2077. The slate district of Wales is of singular interest and magnificence, as those will acknowledge who have visited the chain of mountains, including Snowdon, Plynlimmon, and Cader Idris. These mountains attain an elevation of between 3000 and 4000 feet, their summits are jagged and irregular, their declivities steep and barren, and the neighbouring passes and valleys have all the peculiarities that slate confers; among them, the Dell of Aberglaslyn, viewed from the bridge which unites Merionethshire to the county of Caernarvon, presents a grand and awful feature. The rocks are lofty, lonesome, and black; their sides exhibit terrific and inaccessible precipices; or where the slopes are more gentle, they are covered with the sharp angular fragments, which time and the elements have dislodged from above. The wood-cut at the head of this Section shows the character of the clay-slate upon the coast of North Wales.

Advancing northwards, the mountain chain is broken by the lowlands of Lancashire; but in Westmoreland and Cumberland slate again presents itself, plentifully accompanied by grauwacke, which contributes to the enchanting scenery of the lakes. As black peaks and precipices strewed with slippery and cutting fragments mark the mountains of common slate, so have the grauwacke rocks peculiarities by which they are recognised, and which are no where more evident than in the rounded summits that embosom Derwentwater, as represented in the annexed cut. In their forms, tints, and outlines, there is something indescribably delightful, and they present that rare union of the sublime and beautiful, of which no better idea can be formed, than that suggested by Mr. Burke's comparison: "Sublime objects are vast in their dimensions; beautiful ones comparatively small; beauty should be smooth and polished; the great, rugged and negligent; beauty should shun the right line, yet deviate from it insensibly; the great, in many cases loves the right line, and when it deviates, it often makes a strong deviation; beauty should not be obscure; the great ought to be dark and gloomy; beauty should be light and delicate; the great ought to be solid and even massive." These qualities of that which is sublime,

well apply to the rocks I have before described, and, when blended with the parallel definition of the beautiful, furnish a just notion of the aspect of those now under consideration.

2078. The varieties of MOUNTAIN LIMESTONE (the TRANSITION LIMESTONES of the Wernerians) are the substances that next occur. They are frequently seen immediately incumbent upon clay-slate, and are further distinguished from primitive limestone, or statuary marble, by having a less decidedly crystalline texture. Where this rock lies directly upon slate, it contains few organic remains; but where red sandstone is interposed between it and the slate-rocks, or in proportion as it is distant from the primary and slate-rocks, the relics of organization become more frequent. It then abounds in remains of corals and zoophytes, which now are not known to exist. It often is traversed by veins of calcareous spar, and presents a great variety of colours. It is abundant in Devonshire, South Wales, Derbyshire, and Yorkshire. At Plymouth this rock is seen immediately incumbent upon slate, in a quarry between the Dock and the Town. Its colours are red and grey, streaked with white crystalline veins. It is also seen to great perfection in the Breakwater quarries at Oreston.

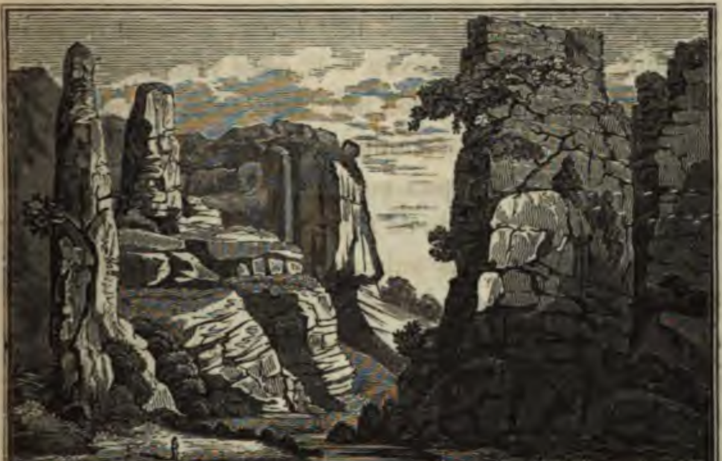
2079. Slate districts often present very curious inflexions and incurvations of their strata. The slate at Plymouth, and the grauwacke of Clovelly in the north of Devon, and the killas upon the coast of Cornwall near Charlestown, are in many places very singularly contorted; and sometimes small undulations present themselves in the laminæ, exactly resembling those left by the ebbing tide upon a gently reclining sand-bank. These appearances may, perhaps, be referred to the action of water upon the materials before they were consolidated.

2080. Limestone strata are also very remarkable for the inflexions and curvatures, referred, not very satisfactorily, by Dr. Hutton to their having been in a soft state at the time they were disturbed from their horizontal position. There are some very curious instances of these curvatures noticed by Saussure; one, in particular, on the road from Geneva to Chamouny, where the small stream of *Nant D'Arpenay* forms a cascade by falling over a perpendicular surface of limestone rock; the strata are bent into regular arches, with the concavity to the left; while in another neighbouring mountain they turn to the right; so that a vertical section of the two would present the figure of S. The top of Benlawers in Perthshire, and the coast of Berwickshire, with many other districts in Scotland, present instances of these singular contortions. Dr. Hutton has given a plate of the bent strata in Berwickshire, from a drawing made by Sir James Hall. I cannot here follow Dr. Hutton and his sagacious commentator through their arguments founded upon these phænomena, they attempt to prove that the undulated strata have received their peculiarities upon level ground; that they have then been elevated, hardened, and often bent and contorted during these processes; and that their irregularities as to position, and their fractures and dislocations have thus occurred, and do not result, as the opposite school would have it, from the falling in of caverns,—a position which they assume as at once accounting for such appearances, and for the retreat of the ocean. Hutton considers the land to have been raised, Werner supposes the waters to have retreated.

2081. The aspect of a country of mountain limestone is peculiar, and generally extremely picturesque. The hills, which, in this country at least, are not very lofty, abound in precipices, caverns, and chasms; and, when upon the coast, form small promontories, and jut out in low but grotesque pillars. The even surfaces are covered with a stinted turf, but the rifts and cracks contain often a soft rich soil in which stately timber trees flourish. The chasms of limestone rocks are often filled with a fine clay, which has, perhaps, sometimes been derived from the decomposition of shaly strata, or sometimes deposited from other causes in the fissures, and the singularities of aspect, and much of the beauty of this rock, is referable to these peculiarities. Thus, upon the banks of the Wye, large and luxuriant trees grace the abrupt precipices, and jut forth from what appears a solid rock. Their roots are firmly attached in some crevice filled with a favourable soil. Sometimes rivers force their way through the chasms; at other times they are empty, and the roofs ornamented by nature's hand with stalactitical concretions of white and glistening spar, which seem like the fretted sculpture of Gothic architecture.

The views of Dovedale, and of Matlock and its vicinity; and the caves of Castleton, are admirably illustrative of the scenery of mountain limestone. Pont-Neath Vaughn, in Glamorganshire, is full of its beauties; and the panorama of Swansea Bay, seen from the Mumbles Point, furnishes a pleasing, characteristic, and perhaps unrivalled, prospect of these rocks.

The banks of the Avon too, in the vicinity of Chepstow, are of mountain limestone. The rock is there impregnated with bitumen, and hence exhales a peculiar and fetid odour when submitted to the blows of the axe or hammer. This is by no means uncommonly the case where the limestone rock, as in the present instance, is in the vicinity of coal. The following sketch may serve to give some idea of the appearance of the mountain limestone of Dovedale, in Derbyshire.



2082. Mountain limestone is an excellent material for building, and many of its varieties are sufficiently indurated to receive a good polish, and are thus employed for ornamental purposes, being cut into vases, chimney-pieces, and the like. Where they abound in corals, and other organic remains, these frequently add to their beauty.

The colours of transition limestone are various, but its essential constituent part is always carbonate of lime. The black variety known under the name of *Lucullite**, or black marble, has long been admired, and is often tastefully manufactured and ornamented by etching upon its surface. It is found in Derbyshire, Sutherlandshire, and Galloway, and appears to derive its colour from carbonaceous matter.

All these limestones are converted into a more or less pure *quick lime* by the operation of a red heat, and are thus often valuable as affording manures, and for other purposes.

2083. The next rock that occurs in point of succession, is RED SANDSTONE. It often rests upon slate, and then, from its position has acquired the term of *old red sandstone*. But a similar substance, or nearly so, also is found lying upon mountain limestone, in which case it has been called *red marl*, or *new red sandstone*.

Entering upon this substance, we come upon distinctly stratified ground; it is very abundant in England, especially in Lancashire, Cheshire, Staffordshire, Shropshire, and Worcestershire; and independent of its embowelled treasures, for it is connected with coal and rock salt, its surface is generally favourable to vegetation, and its soil sufficiently luxuriant. It consists principally of siliceous particles, and oxide of iron, with some argillaceous earth, and more or less calcareous matter. Its beds are often of great thickness, as may be seen in the quarries; it is much used as a building stone, but moulders in consequence of the action of air and moisture upon the oxide of iron. It often contains particles of mica, and fragments and pebbles of old rocks.

---

* A name given to the marble in consequence of the admiration bestowed upon it by Lucius Lucullus. Vide *Plinii Hist. Nat.* 36. 8.

2084. Red sandstone rocks are seen in some parts of Britain in great beauty and perfection, especially where they occur on the coast, or are intersected by rivers. At Ilfracomb, the old red sandstone of the Somersetshire coast is seen lying upon slate; and the junction is interesting to the geologist, the sandstone becoming somewhat slaty, and the slate having a tendency to a granular fracture. The following sketch of Hawthornden, near Edinburgh, shows the characteristic features of the red marl rock, or newer red sandstone; and the ancient castle, with its dungeons and vaults, is constructed of this material. Ridges of red sandstone, containing mica and fragments, sometimes accompany primary rocks, of which a very singular instance occurs

upon the banks of Loch-Beauly, near Inverness; a high range of granite is there bordered by a breccia, very like that of the bed of the Fyers; and a low ridge of red sandstone, of which the valley is also composed, accompanies the series, and seems the detritus of the more ancient and lofty formations.

2085. The slates, grauwackes, and limestones, are in this country the principal seats of the metallic ores; and they form scenery which, gradually decreasing in grandeur and sublimity, increases in softness, variety, and luxuriance. In the lowest sandstone formation, we meet with a variety of bodies of the utmost importance in our arts and manufactures.

2086. A substance which occurs in abundance in many parts of the red strata, is *gypsum* or *sulphate of lime*, known also under the name of *plaster-stone*, *selenite*, and *alabaster*. Near Tutbury in Staffordshire, and near Nottingham, it is found in blocks and veins; and lately a variety, new in England, has been found, called *Anhydrite*. These minerals constitute valuable materials for the ornamental manufactures of Derbyshire.

2087. In the county of Cheshire the red sandstone contains immense beds of *common salt*, most abundant in the valley of the Weaver, and near Middlewich, Northwich, and Nantwich; it is accompanied by gypsum. The first stratum was discovered about 150 years ago, in searching for coal. It begins about 30 yards from the surface, and is 25 yards thick; below this, and separated from it by 10 or 12 yards of indurated clay, is another bed of salt, the extent of which is unknown; in many places it is nearly pure, in others tinged with oxide of iron and clay. This pit is at Northwich; and at other places there are very abundant brine springs. A most remarkable circumstance in the Northwich mine is the arrangement of the salt, giving rise to an appearance something like a mosaic roof and pavement, where it has been horizontally cut. The salt is compact, but it is arranged in rounded masses, five or six feet in diameter, not truly spherical, but each compressed by those that surround it, so as to have the shape of an irregular polyëdron. The Wernerians regard the salt as having merely crystallized here from its aqueous solutions; the Huttonians consider the water to have been evaporated by heat. The large pit at Northwich presents a very singular spectacle when duly illuminated; it is a circle of nearly two miles in circumference, the roof is supported by massive pillars of salt, and the effect is heightened by the variety of colours it presents*.

2088. *Coal* is the most important product of these middle strata. What is called a *coal field*, or *district*, or sometimes a *coal basin*, may be regarded as a concavity, varying greatly in extent, from a few to many miles, and containing numerous strata or seams of coal of very various thickness, alternating with sandstone, clays, and soft slate or *shale* containing impressions of vegetables and sometimes the remains of fresh water shell-fish. The parallelism of these strata is generally well preserved. The whole arrangement is seldom any where quite horizontal, and never vertical, but almost always more or less inclined. Beneath each stratum of coal, there is often one of soft clay, or *clunch*, which rarely contains the organic remains of the overlying shale: and although the alternating strata of coal be very numerous, it is seldom that more than three or four will afford profitable occupation to the miner. The upper seam is commonly broken and impure, and few beds, less than two or three feet in thickness, are followed down to any considerable depth. The depth of the mines will of course greatly vary, according to the inclination of the strata, the time they have been worked, and other circumstances. Our deepest mines are in the counties of Durham and Northumberland, and the thickest beds are found in Staffordshire. The most productive vary from six to nine feet.

---

* See *A Sketch of the Natural History of the Cheshire Rock-salt District.* By Henry Holland, Esq.—*Geol. Trans.* i. 38.

2089. There are several varieties of coal, but, as far as their economical applications are concerned, they may principally be reduced to two. The coals of Lancashire, Scotland, and most of those raised upon the west of England, burn quickly and brilliantly into a light ash: while the coal of Northumberland and Durham, becomes soft and puffy, spouts out bright jets of flame, requires poking to continue in combustion, and produces bulky cinders, which, if urged in a violent fire, or mixed with fresh coals, run into slags and clinkers.

2090. Though coal is chiefly found in the geological position I have mentioned, constituting the *independent coal formation* of Werner, it is likewise found in other situations, amongst newer rocks, and sparingly in alluvial soils. But in this country, the main coal formations are marked by their position; their contiguity to limestone and often to slate; by micaceous grits and sandstones; and, above all, by shale with vegetable impressions, decomposing into tenacious blue clay.

2091. The greater number of geologists are now unanimous as to the vegetable origin of coal; and, indeed, its composition, the abundance of vegetable bodies with which it is often associated, and the gradual transitions of wood into coal, discoverable in many parts of the world, may be considered as satisfactory evidence upon this subject: but how it has been formed, is another and more intricate question.

Dr. Hutton considered coal strata to have been produced by the operation of subterranean heat, in the manner already described, acting upon vegetable bodies and charcoal under exceeding pressure, which prevented the usual phænomena of combustion, and hindered the escape of the inflammable part. Sometimes, he observes, more or less bitumen has been driven off, for we find it in other strata.

By Mr. Williams, antediluvian timber and peat bog are regarded as the source of our present coal; and a variety of curious circumstances, which the minute history of coal fields presents, have been adduced as favourable to his conclusions.

2092. The coal miner is often seriously interrupted in his proceedings, by large fissures or breaks in the strata, and by veins of a hard black rock, which cut through the coal, sometimes merely dividing it, at others throwing it out of its former position. It is in the neighbourhood of these *dykes* and *troubles*, as they are called by the miners, that immense quantities of carburetted hydrogen gas are frequently evolved, though the coals themselves, and the cavities in the strata, also yield it; it constitutes the *fire-damp* of the mines; and when it has any where collected so as to constitute more than $\frac{1}{13}$ of the volume of atmosphere, it becomes explosive whenever a flame is presented to it, and the source of such dreadful destruction, that the mind recoils from the recital. Formerly the miners, in these dangerous situations, availed themselves of the light obtained by the collision of flint and steel, which, however, was by no means free from danger, and has been completely superseded by Sir Humphry Davy's safety lamp.

2093. Another substance which very often attends coal formations, is *argillaceous iron-stone*, both in layers and nodules; and although a poor ore of iron, very seldom yielding more than 30 *per cent.* of metal, it becomes, from its association with coal and limestone (substances required for its reduction), a most important natural product; it is the main source of the enormous quantities of iron manufactured in this country; and the history of the various difficulties which have been surmounted in completing the processes of its reduction, presents an unrivalled picture of skill, ingenuity, and perseverance (725).

2094. Leaving the districts of red sandstone and red marl, we observe a change in the general aspect of the country. There are no steep or abrupt precipices; the hills assume a more picturesque and luxuriant character, and the rugged features of primary country, are here softened down into gentle slopes and verdant plains.

The rocks which now occur are chiefly varieties of limestone and sandstone, particularly prolific in organic remains; among them we discern a number of species of which no living semblance is now in existence.

Corals, zoophytes, ammonites, belemnites, nautili, and a variety of other fossil remains, are found in the ARGILLACEOUS LIMESTONES, which succeed in position to the red sandstone, and which are often called *white* and *blue lias limestone.* The coast of Dorsetshire, between Weymouth and Lyme, presents a very interesting section of these strata; and their continuation through the country is well entitled to the notice of the geologist. They decompose into marl, and furnish an ingredient in the best water-cements. Sometimes they are of a peculiar yellow colour, and contain magnesia, when the fossil remains are less frequent.

2095. These strata are succeeded by a species of stone, often called *Bath-stone,* from its abundant occurrence in the vicinity of that city, and *freestone,* or OOLITE, of which *Portland-stone* is a notorious variety. There then commonly occur various SANDSTONES, with veins of chert and oxide of iron; and, lastly, we arrive at CHALK, and superincumbent ALLUVIAL MATTER.

2096. The examination of the fossil remains in these strata, leads to conclusions of much interest and importance. In the strata upon the coast of Dorsetshire, below the chalk, we find the remains of an animal, which has generally been regarded as a crocodile, or alligator*, but there are no fossil relics of mammiferous land animals, either here, or in the chalk itself; whence it has been concluded, that oviparous quadrupeds are of more ancient date than those of the viviparous class, and that dry land and fresh water existed before the formation of our present chalk. In the vicinity of Paris the chalk is covered by a coarse shell limestone, in which the bones of mammiferous sea animals have been found by Cuvier; but no bones of mammiferous land quadrupeds occur, till we reach the more recent and superincumbent strata.

---

* Sir Everard Home, in examining the fossil bones of this animal, has thrown considerable doubt upon the above conclusion; and, from a peculiarity in the structure of its spine, resembling that of the *proteus,* has called it *proteorrhachius.*

2097. The *chalk* presents the geologist with much matter of speculation. In England it is a very abundant formation, and the round-backed hills covered with verdure which mark the eastern counties, are very characteristic of it. Salisbury Plain and Marlborough Downs form a centre, whence the chalk emanates, in a north-eastern direction, through the counties of Buckingham, Bedford, and Cambridge, and terminates on the Norfolk coast. In an easterly direction it traverses Hampshire, Surry, and Kent, and terminates at Dover; and another arm passing through Sussex, east south-east, forms the South Downs, and the lofty promontory of Beachy Head. Parallel ridges of sandstone generally accompany the chalk, and in Wiltshire, Berkshire, and some other counties, large blocks of granular siliceous sandstone lie scattered upon its surface; of these the celebrated druidical relics, called *Stonehenge*, appear to have been constructed, with the exception of one of the blocks, which is of greenstone. The lower beds of chalk are generally argillaceous, or marly, and contain no flints, and few organic remains. The upper beds abound in fossil relics, of the kinds before alluded to, and in flints sometimes regularly arranged in distinct nodules, at other times remarkably intersecting the chalk in thin seams. The formation of flint has been much speculated upon, but no plausible theory has yet been adduced in regard to it.

2098. In the south of England the chalk is covered with gravel and clay, the history of which is extremely curious, on account of the fossils which they contain, and the evidence they afford of repeated inundations of salt and fresh water upon the same spot. There are two celebrated concavities filled with such materials, which have been called the London and the Isle of Wight Basins. The former is bounded by the chalk-hills proceeding from Wiltshire to the south of the Kentish coast, in one direction, and to the northern point of the Norfolk coast in another; and it is open to the ocean upon the Essex, Suffolk, and Norfolk coasts, which show sections of its contents.

The numerous wells which have been dug in the neighbourhood of London, and the canals, tunnels, and other excavations and public works which have been carried on, have lately made us acquainted with many curious facts respecting the contents of this basin.

It deserves remark, that all the bones of viviparous land quadrupeds have either been found in the uppermost fresh water deposits, or in those alluvial formations of the ocean, which appear to have been the result of violent transportations of materials, rather than of quiet depositions; so that it is probable these animals began to exist during that state of the world which preceded the last inundation of the sea.

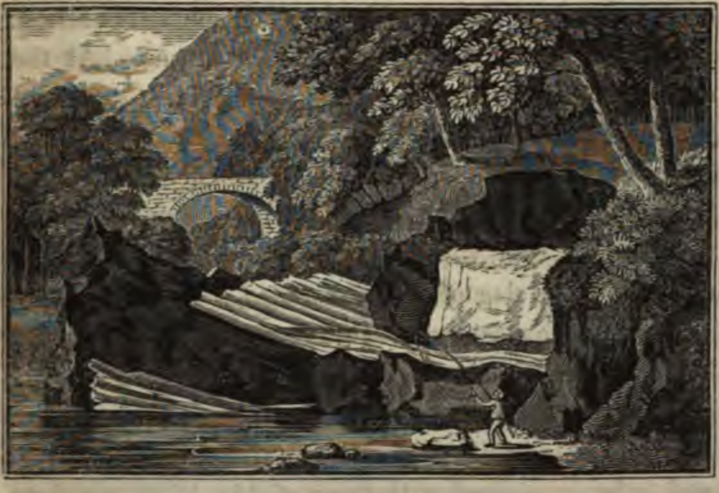
The *palæotheria*, *anaplotheria*, and other unknown genera described by Cuvier, are found in the lowest parts of the upper fresh-water formation, placed immediately under the upper marine formation. Some oviparous quadrupeds and fresh-water fish are found along with them, and they are covered by alluvial deposits, containing marine relics.

The unknown or extinct species belonging to known genera, such as the *mastodon*, *elephant*, *hippopotamus*, and *rhinoceros*, are never associated with the more ancient or extinct genera, but are discovered usually in the sea-water deposits; and the bones of species resembling those that now exist, are found upon the sides of rivers, or in the bottoms of ancient lakes and marshes, or in peat-bogs, or in caverns and fissures of rocks; and, in consequence of their superficial situation, they are generally much injured.

2099. Of a very singular and important series of rocks, I have yet made no mention. They occur indiscriminately in primary and secondary countries, and are not less varied in their characters and aspects, than in their situation. These are the *trap-rocks* of the Wernerians, and the *whinstones* of Dr. Hutton. They include the rocks called GREENSTONE, BASALT, AMYGDALOID, and TOADSTONE, and are distinguished into primary, transition, and floetz traps, by the school of Freyburgh.

By the term *greenstone*, we mean a compound of hornblende and feldspar, differing extremely in its appearance, being sometimes so fine grained as to appear homogeneous; at other times presenting distinct, and often large, crystals of hornblende. *Basalt* is always a homogeneous rock, and abounds in black oxide of iron. Its cavities are often filled with calcareous spar, zeolite, and agate nodules.

Greenstone is met with in many parts of England immediately upon granite and primary rocks; and it assumes the character of its neighbours, breaking into large blocks and masses of very irregular appearance. In this state it is seen in Cornwall, at the Lizard-Point. Upon the north side of the Welsh mountains, a chain of greenstone follows the slate, which, in some places, is columnar, as upon Cader Idris, and it forms a singular concavity near the summit of that mountain, very like the crater of a volcano. In Derbyshire these rocks are among the transition series of Werner. They form strata, and fill cavities in the limestone. In coal-fields they constitute dykes, or veins; and, among the newest and secondary strata, they are seen in sandstone at Edinburgh, and upon the coast of Antrim they are incumbent upon, and alternate with, chalk. The annexed wood-cut, taken from a sketch by Dr. Mac Culloch, en-



graved in the *Geological Transactions*, Vol. iii., represents a remarkable dislocation occurring at Gow's

Bridge, in Glentilt, in Scotland, of the schistose strata by the black mass of hornblende rock, which also contains an embedded mass of marble.

3000. The common observer, to whom a piece of basalt is presented, would presently announce it to be the produce of a volcano, and the analogy between it and lava is most striking. This alone would justify us in concluding, that whinstone is the produce of fire. But the Huttonian hypothesis, as applied to its origin, becomes much more satisfactory, when we contemplate the effects produced upon the strata into which it has been thrown, or upon the substances in its vicinity. Thus the sandstone of Salisbury Craigs, near Edinburgh, is broken, indurated, and even apparently fused by its irruption. The soft white limestone of the county of Antrim, where in contact with the basaltic dyke, is hardened and rendered crystalline, like marble and calcareous spar; and the coal in the same county is coaked, as it were, where touched by the whinstone. At the same time, the dykes themselves bear evident marks of igneous fusion. They are more regularly crystallized in the centre than upon the surface, an effect which may be well referred to the different rates of cooling, in the melted mass, and which may even be imitated artificially with the slag of an iron furnace.

Perhaps the most remarkable phænomenon concerning basalt, is its occasional columnar structure, an appearance which lava sometimes assumes. Upon this subject Sir James Hall's experiments are of extreme interest; and, when conjoined with those of Mr. Watt, produce a further, and, indeed, almost irresistible evidence in favour of the igneous origin of basalt.

3001. In accounting for the humid origin of basalt, the Neptunists refer to the columnar cracking of clay, mud, starch, *&c.*, during drying ; and in this they fancy an analogy to basaltic columns ; but, in these cases, there are always chasms and vacuities produced by the shrinking of the mass ; whereas the columns of basalt are so closely connected, that the thin blade of a knife can scarcely be thrust between them. Upon the whole, the Huttonian theory may be considered as no where more free from objections, than where it applies to basalt ; while the hardening, contortions, and breaking of the strata by whin dykes, and the numerous analogies of basalt and lava, are to the Neptunians paradoxes which admit of no solution.

3002. Of columnar basalt, the British dominions present the noblest specimens in the known world. Upon the coast of Antrim, in Ireland, massive and columnar basalt is seen in all its varieties, the former abounding in deep and lofty caverns, the latter presenting various

façades to the ocean. The Giant's Causeway, a small part of which, with the neighbouring coast, is shown in the above wood-cut, consists of three piers of columns, which extend some hundred feet into the sea. It is surrounded by precipitous rocks, from two hundred to four hundred feet high, in which there are several striking assemblages of columns, some vertical, some bent or inclined, and some horizontal, and, as it were, driven into the rock. Bengore, which bounds the Causeway on the east, consists of alternate ranges of tabular and massive, with columnar basalt. But amongst the various and grand objects on this coast, Pleskin is perhaps the most striking; it presents several colonnades of great height and regularity, separated from each other by tabular basalt; and at Fairhead there is a range of columns of from 10 to 20 feet in diameter, and between 200 and 300 feet high, supported upon a steep declivity, and forming a terrace which towers nearly 600 feet above the waves beneath. He who would really see the sublime should visit this stupendous promontory.

Another basaltic district, which I am inclined to regard as exceeding the former in magnificent peculiarities, is that which presents itself in sailing down Loch-Nagaul, in Mull, towards the Isle of Tiree. The coast of Mull, upon the right and left, exhibits the step-like appearance of basaltic rocks in great perfection, and has fine caverns and columns; the islands of Ulva and Gometra rise with the abrupt and irregular precipices common to this formation. The Treshamish Isles exhibit columnar and massive basalt, and in the midst of this curious panorama, Staffa presents itself. The columns, which are from 30 to 50 feet high*, are approached by a fine causeway, rising gradually from the deep, and they appear to support an immense weight of tabular basalt. The pillars are perpendicular, inclined, and in places extremely curved ; and in the Cave of Fingal the ranges of columns extend in long perspective into the interior of the rock, presenting a scene of such unrivalled grandeur, as hitherto to have foiled all attempts of the poet to describe, or of the painter to represent. The wood-cut at the head of the next Section, copied from Dr. Mac Culloch's sketch, represents the Causeway and entrance of the Cave.

---

* See Dr. MAC CULLOCH's *Description of the Western Islands of Scotland.* Vol. ii. p. 1.

SECTION IV. *Of Metallic Veins.—Of the General Causes of the Decomposition of Rocks.—Of Volcanoes: and of the Analysis of Soils.*

3003. BESIDES the veins of lapideous substances, the fissures filled with debris and rubbish, the dykes, the beds of salt, and the fields of coal, there are diffused through the strata a variety of other treasures, among which the metals are of the utmost interest and importance. By the term *Mineral Vein,* we mean a separation in the continuity of a rock of determinate width, but extending indefinitely in length and depth, filled with metallic ores, and crystalline substances, differing from the rock itself.

Nearly all rocks are occasionally thus traversed, but the middle series are those in which metals are most abundant. In Cornwall, for instance, tin occurs both in the granite and slate: but it is most abundant in the latter, and the vein occasionally runs between the two rocks, so that one wall consists of granite, and the other of slate. The metal is often separated from the rock by thin layers of clay, or of stony materials, called *Deads*, which also intermix with the ore, and form its *gangue*, or *matrix*.

3004. The richest metallic veins run, without exception, east and west. Those which run north and south being usually filled with stony materials. The latter veins appear of posterior date to the former, for they often intersect them, throwing them out of their regular course; generally a few inches only east and west, but many fathoms north and south. These *cross courses* often interfere with the treasures of the metallic vein, though, when solid, they are sometimes of great service in keeping out water.

3005. The extent to which veins may be pursued, is extremely various, and depends much upon accidental circumstances. Sometimes a cross course cuts the vein, and puts an end to the miner's hopes, he being unable to discover its continuation after such interruption; sometimes the depth of the vein becomes so great, that it cannot be prudently pursued; sometimes a rich lode of metal suddenly disappears, or vanishes into thin strings, which, though often quite lost, occasionally reunite into a good vein, or bunch of metal. So that, taking all these circumstances into account, between two or three miles is usually the utmost extent to which a vein has been pursued*.

---

* See a valuable paper on the *Veins of Cornwall*, by Mr. W. Phillips. *Geol. Trans.* Vol. ii., and also annexed to his *Selection of Facts*.

3006. Veins vary in width, from an inch or two, to 30 or 40 feet, but the middle-sized veins are usually most prolific, the larger becoming relatively poor. The influx of water was formerly an insuperable impediment to the pursuit of a vein, and remains now a serious and expensive obstacle to mining. Formerly many veins in Cornwall were only worked for tin, which, at greater depths, have lately yielded abundance of copper; but in Cornwall copper is never found without water, and all the mines of that metal require drainage by engines, or other means.

3007. Concerning the original formation of metallic veins, there has been considerable collision of sentiment among geologists; but two circumstances seem sufficiently obvious; one, that they are of later date than the containing strata, that they are not contemporaneous; and the other, that their contents have been in a fluid state. The former position is indicated by their intersecting different strata; the latter, by the crystalline forms of the substances they contain. The Neptunians tell us that veins have been filled by metallic and lapideous solutions flowing in from above, but they do not inform us of the nature of the solvent which held the different bodies they present; nor can we guess why its contents are deposited exclusively in the vein, and not found upon the adjacent surface.

3008. The Plutonists consider veins as filled from below, by the injection of matters in igneous fusion; and in the shifting, breaking, and dislodgement of the strata, they read the force with which these operations have been performed. The validity of hypotheses is only to be estimated by their accordance with facts;

and although there be many inexplicable phænomena attending metallic veins, yet the nature of their contents is such as to favour the igneous hypothesis, and to lead to the belief that fire, not water, has been the grand solvent of which nature has here availed herself. That the metals have passed from the fluid to the solid state, seems sufficiently obvious, from their crystalline form; and it is much more probable that they should have been liquefied by heat than by any other solvent.

Sulphur is very commonly found united to metallic bodies, and the greater number of metallic ores contain that element. Such compounds are easily produced by the artificial agency of fire, but with great difficulty by any other process.

3009. A very curious fact in the history of veins is, that they are of different dates, for one vein often intersects another, and we are thus enabled to judge of their relative ages. In the county of Cornwall, one of the richest mining districts of the world, we observe some remarkable circumstances of this kind. Where a copper and a tin vein, for instance, meet, the former always cuts through the latter, and generally throws it out of its old course, greatly to the distress of the miner, who sometimes cannot find its continuation, or at least is put to much difficulty and expense to do so. It appears, therefore, that tin veins are invariably older than those of copper. Sometimes, as in Derbyshire, the metallic ores lie in large longitudinal cavities, called *pipe veins*.

3010. In searching for veins of the useful metals, there are certain indications of which the experienced miner sometimes profitably avails himself. Thus, a green earthy matter is a good symptom in a tin mine; a brown ochrey earth, and compact iron pyrites, are regarded as favourable omens in a copper mine.

Detached pebbles of ore, or fragments of vein-stones, have sometimes led to the riches of the vein, and tin has especially been thus discovered in Cornwall.

In older mineralogical works we read much upon these and other subjects. Flames of light have been described as playing over a district which afterwards has been found to contain subterranean riches, and this may have arisen from the good electrical conducting powers of the vein. The waters issuing from the soil sometimes hold metallic salts in solution, and repositories of the metals have been discovered by circumstances of this kind. Copper veins tinge waters blue, and a piece of grease put into them becomes rapidly stained of that colour.

There is no popular notion more common than that metals grow in the veins: an idea which may very probably have originated from observing the depositions of one metal by the introduction of another into its solution, as when silver is precipitated by the introduction of a plate of copper into its solution, or copper by iron.

3011. Districts rich in the metals are generally barren, and seem peculiarly dreary and desolate to the traveller. This partly arises from the nature of the strata; partly from the heaps of rubbish and hills of stone thrown upon the surface; and partly from the operations carrying on in the vicinity, being inimical to vegetation. The high road through Cornwall, especially near Redruth, is an excellent specimen of this kind of country; while, at the same time, the romantic beauty and luxuriant vegetation of many parts of that county, and of Devonshire, prove that exterior cultivation is not always incompatible with internal riches. The neighbourhood of the Parys Mountain, in Anglesea, is singularly marked by sterility and gloominess. The soil, naturally unproductive, is rendered more so by the poisonous waters that traverse it, and the sulphurous vapours that float around. There are not only no shrubs and trees, but the barrenness is unrelieved even by a single blade of grass, or the rusty green of a hardy lichen.

3012. I have hinted above at the relative permanence and durability of the different kinds of rocks, and it has been found that the unstratified, or primary, substances, are least acted upon by the elements; that these have retained their great and pristine elevation, while the secondary strata have been washed from their sides and summits, whose rugged and abrupt outline records this devastation. Every one who views the mountain side strewed with immense blocks of materials transported from distant summits, and discovers the dells and valleys filled with fragments and pebbles of the neighbouring rocks, will allow that a constant system of disintegration and decay is here carrying on; but the geologist, not content with the mere observance of the fact, will endeavour to trace it to its source, and follow it up to its ultimate effect.

3013. The change of temperature to which the earth's surface is constantly submitted, is one great cause of the slow destruction of its most solid and durable constituents; and when to this is added the gigantic power with which water, in becoming ice, opposes the obstacles to its expansion, we have an agent nearly resistless.

The fissures that occur between the blocks and masses of the granites, porphyries, and similar rocks, become filled with water, which, in the act of freezing, expands so as slowly to remove them from each other; their edges and angles become thus open to the attacks of the weather, and by a slow dislodgement they fall into the valleys or rivers, or are at once cast into the ocean. Where the materials are of a more yielding and frangible texture, this destruction is proportionally rapid, and the influence of the weather upon slate mountains, is often such as to produce hills of fragments at their feet: the softer substance of the secondary and horizontal strata is, of course, yet more easily and quickly degraded,

3014. Masses of rock, thus loosened from their original beds, become new and powerful instruments of destruction; they roll down the precipices, wearing themselves and the surface that bears them, and, if near the sea, or carried thither by rivers, they become "a part of the mighty artillery with which the ocean assails the bulwarks of the land;" they are impelled against the coasts, from which they break off other fragments; and the whole thus ground against each other, whatever be their hardness, are reduced to gravel; the smooth surface and rounded masses of which are convincing proofs of the manner in which it was formed.

3015. It is by operations of this kind, not performed in a day, but in ages, that nature has indented and carved out the earth's surface; that the rivers seem to have cut their own beds; that the land is undergoing gradual demolition; and that the materials which we have elsewhere considered as consolidated at, and elevated from, the bottom of the ocean, are gradually restoring to the parent deep. These are mechanical agents, but they are not unassisted by the chemical energies of matter; and, in this respect, the solvent powers of water may be contemplated as effecting most important changes.—KIDD's *Essay*, p. 181.

3016. By impregnation with carbonic acid, water acquires a great solvent power over carbonate of lime (642,) and in trickling through, such strata becomes saturated with it, and, on exposure, again deposits it, in consequence of the escape of the gaseous solvent; it is thus that the stalactitical concretions of limestone caverns are produced, as in the Fluor Mine, and Peak Cavern of Derbyshire; and, in many cases, the once empty chasms are entirely choaked up by this sparry deposit. The power of incrustation, thus possessed by some waters, is such as rapidly to cover extraneous bodies thrown into them with a calcareous coating, of which the petrifying spring of Matlock furnishes a good example.

3017. The sands upon flat coasts are sometimes agglutinated by this action of water, so as to produce a new rock; or, as the Wernerians would call it, a new formation. This has probably been the case with the stone in which the *galibi*, or human skeletons of Guadaloupe, are found (*Phil. Trans.* 1816), and the process is constantly going on upon the coast of Cornwall, in the parish of St. Columb, where the water, having percolated the neighbouring rocks, becomes slightly carbonated and ferruginous, and thus serving as a cement to the sand, produces a hard stone, which is used as a building material, and for making cattle-troughs. In the walls of some of the oldest churches in Cornwall, as in St. Burian, Gwithian, Crantock, Cubert, *&c.*, are large masses of this *sandstone*, which has thus long resisted decomposition. When water is hot, and slightly alcaline, it dissolves siliceous earth, as shown by the deposits of the Geysers, or Boiling Fountains of Iceland.

3018. Some rocks suffer, in consequence of the action of air and water upon the black oxide of iron which they contain, and which, in passing into the state of brown oxide, occasions a crumbling of the mass. Much of the soil upon the coast of the county of Antrim, in Ireland, is thus derived from the decomposition of basalt, which, however, in other cases, singularly resists change, as in Staffa, where the columns, though exposed to the violence of the ocean, retain a sharp angularity and black colour. These differences depend upon the degree of induration of the basalt.

3019. Rocks containing alcali seem often to decompose rapidly, in consequence of the loss of that ingredient. The quick disintegration of much of the Cornish granite is well known, and it furnishes a valuable material for the manufacture of pottery. The feldspar of this granite contains a considerable portion of potassa, but the white earth into which it is resolved yields no traces of it.

3020. The chemical agencies of different bodies presented to each other in the strata, are also often connected with the production of entire new substances. Thus the decomposition of pyrites in chalk produces sulphate of lime; in aluminous slate it gives rise to the production of alum; and in the cliffs at Newhaven, on the Sussex coast, a very curious series of changes is going on. A stratum of marl, containing decomposing pyrites, lies upon the chalk, which gives rise to the formation of sulphate of alumina; this is decomposed by the chalk; and aluminous earth, selenite, and oxide of iron, are the results.

3021. Thus, by mechanical operations and chemical changes, sometimes separate and sometimes united, the rugged peaks and abrupt precipices are gradually wearing and softening down, and giving rise to rounded summits, gentle slopes, and habitable surfaces. The detritus so produced is carried by rills, and brooks, and rivers, towards the low lands, where it is deposited; or it is transported towards the sea, where it forms bars and islands at the mouths of rivers; or it is employed in levelling uneven surfaces, and filling cavities and basins, as where the rivers are broken in their course by the intervention of lakes, all of which are filling up, as may be learned even by hasty inspection. This is no where more conspicuous than in the waters which adorn the scenery of Westmoreland and Cumberland, especially Derwent Water, at the Borrowdale extremity of which the meadow is annually increasing, and adding to the circumjacent field; and the examination of the bank between Derwent and Bassenthwaite, shows that the two lakes were once united, and that the present separation is alluvial matter, or a bar thrown up by the concurrent streams of Newland's Water, on the west, and the Greta on the east. The filling up of lakes, until they ultimately become merely a part of the river that now traverses, but once fed them, is too obvious to require further illustration; it is the reason why the stream, which has its exit from a lake, is generally clear, while the torrents which supply it are loaded with matters in minute mechanical division.

3022. While the destructive agencies of the elements are thus called into action for the production and increase of habitable surface, we observe other causes tending to the same effect, and none more wonderful than the incessant labours of those insect tribes which collect and accumulate solid matter from the ocean, and form the rocks of coral common in the seas of warm climates.—KIDD's *Essay*, p. 219.

3023. But the most striking sources of decay and reproduction, are those dependent upon volcanic phænomena.

The form of volcanic hills is usually conical, of which the outline of the Bay of Naples presents a fine panorama. One of its hills serves to give some idea of the vast powers of the subterranean agents; it is about 1000 feet high, and three miles in circumference, and was raised, in 1238, in a single night*.

3024. In June 1811, a volcano was discovered in the sea off St. Michael, and it formed an island about a mile in circumference.—*Phil. Trans.*, 1812.

3025. To describe the phænomena of volcanic eruptions with all attending circumstances, would be foreign to our present purpose; but as the same causes may have been active in producing other geological phænomena, it becomes right to mention the subject.

Until lately, the cause of volcanic fire was referred to sulphur, coal, and other common inflammable matters, which were supposed to be burning in immense masses within the earth, and thus to give rise to the tremendous explosions and ejections of lava and stones attending the eruption; but the products ill accord with such an explanation. Earthy, alcaline, metallic, and stony bodies united, form the lava; and steam and hydrogen gas accompany its throwing forth; and as the products of combustion always have a reference to the combustible, such matters were not likely to be produced from sulphur or coal.

---

* See Sir Wm. Hamilton's Paper in the *Phil. Trans.* for 1771.

The discoveries of Sir H. Davy have enlightened this, as well as every other branch of chemistry, and from them we may deduce a very adequate solution of the problem of volcanoes, for we have only to suppose the access of water to large masses of those peculiar metals which constitute the alcaline and earthy bases, and we are possessed of all that is wanted to produce the tremendous effects of earthquakes and volcanoes; for what power can resist the expansive force of steam, and the sudden evolution of gaseous fluids, accompanied by torrents of the earths in igneous fusion, which such a concurrence of circumstances would give rise to, and which are the actual concomitants of volcanic eruptions?

From the same source the Huttonian theory derives great additional plausibility, for its feeble parts were those which related to the required expansive forces, to the intense continuance of heat, to its occasional increase and decrease, and to the existence of a species of fuel adequate to the various effects that have been described. The metals of the earths are equal to the production of all these complicated and apparently incompatible effects, and these and water are the sole agents required.

3026. The principal circumstances that tend to the formation of soils, and to modify their composition, have been adverted to in this Chapter; and, from the properties of their component parts, elsewhere detailed, the means of analyzing them are to be deduced; but as this is a subject upon which the agriculturist may sometimes find it expedient to employ himself, I insert the following popular instructions upon it, from Sir H. DAVY's *Elements of Agricultural Chemistry:*

"In cases when the general nature of the soil of a field is to be ascertained, specimens of it should be taken from different places, two or three inches below the surface, and examined as to the similarity of their properties. It sometimes happens, that upon plains the whole of the upper stratum of the land is of the same kind, and, in this case, one analysis will be sufficient; but in valleys, and near the beds of rivers, there are very great differences; and it now and then occurs that one part of a field is calcareous, and another part siliceous; and in this case, and in analogous cases, the portions different from each other should be separately submitted to experiment.

"Soils, when collected, if they cannot be immediately examined, should be preserved in phials quite filled with them, and closed with ground-glass stoppers.

"The quantity of soil most convenient for a perfect analysis, is from 200 to 400 grains. It should be collected in dry weather, and exposed to the atmosphere till it becomes dry to the touch.

" The specific gravity of a soil, or the relation of its weight to that of water, may be ascertained by introducing into a phial which will contain a known quantity of water, equal volumes of water and of soil, and this may be easily done by pouring in water till it is half full, and then adding the soil till the fluid rises to the mouth; the difference between the weight of the soil and that of the water will give the result. Thus, if the bottle contains 400 grains of water, and gains 200 grains when half filled with water and half with soil, the specific gravity of the soil will be 2, that is, it will be twice as heavy as water; and if it gained 165 grains, its specific gravity would be 1.825, water being 1.000.

" It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains; these substances being always most abundant in the lighter soils.

" The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus, siliceous soils are generally rough to the touch, and scratch glass when rubbed upon it: ferruginous soils are of a red or yellow colour; and calcareous soils are soft.

" 1. Soils, though as dry as they can be made by continued exposure to air, in all cases still contain a considerable quantity of water, which adheres with great obstinacy to the earths and animal and vegetable matter, and can only be driven off from them by a considerable degree of heat. The first process of analysis is, to free the given weight of soil from as much of this water as possible, without, in other respects, affecting its composition; and this may be done by heating it for ten or twelve minutes over an Argand's lamp, in a basin of porcelain, to a temperature equal to 300 Fahrenheit; and if a thermometer is not used, the proper degree may be easily ascertained by keeping a piece of wood in contact with the bottom of the dish; as long as the colour of the wood remains unaltered, the heat is not too high; but when the wood begins to be charred, the process must be stopped. A small quantity of water will perhaps remain in the soil even after this operation, but it always affords useful comparative results; and if a higher temperature were employed, the vegetable or animal matter would undergo decomposition, and, in consequence, the experiment be wholly unsatisfactory.

" The loss of weight in the process should be carefully noted, and when in 400 grains of soil it reaches as high as 50, the soil may be considered as in the greatest degree absorbent, and retentive of water, and will generally be found to contain much vegetable or animal matter, or a large proportion of aluminous earth. When the loss is only from 20 to 10, the land may be considered as only slightly absorbent and retentive, and siliceous earth probably forms the greatest part of it.

" 2. None of the loose stones, gravel, or large vegetable fibres should be divided from the pure soil till after the water is drawn off; for these bodies are themselves often highly absorbent and retentive, and, in consequence, influence the fertility of the land. The next process, however, after that of heating, should be their separation, which may be easily accomplished by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres, or wood, and of the gravel and stones, should be separately noted down, and the nature of the last ascertained; if calcareous, they will effervesce with acids; if siliceous, they will be sufficiently hard to scratch glass; and if of the common aluminous class of stones, they will be soft, easily cut with a knife, and incapable of effervescing with acids.

"3. The greater number of soils, besides gravel and stones, contain larger or smaller proportions of sand, of different degrees of fineness: and it is a necessary operation, the next in the process of analysis, to detach them from the parts in a state of more minute division, such as clay, loam, marl, vegetable and animal matter, and the matter soluble in water. This may be effected in a way sufficiently accurate, by boiling the soil in three or four times its weight of water; and when the texture of the soil is broken down, and the water cool, by agitating the parts together, and then suffering them to rest. In this case, the coarse sand will generally separate in a minute, and the finer in two or three minutes, whilst the highly-divided earthy, animal, or vegetable matter will remain in a state of mechanical suspension for a much longer time; so that, by pouring the water from the bottom of the vessel, after one, two or three minutes, the sand will be principally separated from the other substances, which, with the water containing them, must be poured into a filter, and, after the water has passed through, collected, dried, and weighed. The sand must likewise be weighed, and the respective quantities noted down. The water of lixiviation must be preserved, as it will be found to contain the saline and soluble animal or vegetable matters, if any exist in the soil.

"4. By the process of washing and filtration, the soil is separated into two portions, the most important of which is generally the finely-divided matter. A minute analysis of the sand is seldom or never necessary. and its nature may be detected in the same manner as that of the stones or gravel. It is always either siliceous sand, or calcareous sand, or a mixture of both. If it consist wholly of carbonate of lime, it will be rapidly soluble in muriatic acid, with effervescence; but if it consist partly of this substance, and partly of siliceous matter, the respective quantities may be ascertained by weighing the residuum after the action of the acid, which must be applied till the mixture has acquired a sour taste, and has ceased to effervesce. This residuum is the siliceous part; it must be washed, dried, and heated strongly in a crucible; the difference between the weight of it, and the weight of the whole, indicates the proportion of calcareous sand.

"5. The finely-divided matter of the soil is usually very compound in its nature; it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportion of these with tolerable accuracy, is the most difficult part of the subject.

" The first process to be performed, in this part of the analysis, is the exposure of the fine matter of the soil to the action of muriatic acid. This substance should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter; but diluted with double its volume of water. The mixture should be often stirred, and suffered to remain for an hour, or an hour and a half, before it is examined.

" If any carbonate of lime or of magnesia exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron; but very seldom any alumina.

" The fluid should be passed through a filter; the solid matter collected, washed with rain-water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution, which, if not sour to the taste, must be made so by the addition of fresh acid, when a little solution of prussiate of potassa and iron must be mixed with the whole. If a blue precipitate occurs, it denotes the presence of oxide of iron, and the solution of the prussiate must be dropped in till no farther effect is produced. To ascertain its quantity, it must be collected in the same manner as other solid precipitates, and heated red; the result is oxide of iron, which may be mixed with a little oxide of manganese.

" Into the fluid freed from oxide of iron, a solution of neutralized carbonate of potash must be poured till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alcaline salt.

" The precipitate that falls down is carbonate of lime, it must be collected on the filter, and dried at a heat below that of redness.

" The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if any exist, will be precipitated from it, combined with carbonic acid, and its quantity is to be ascertained in the same manner as that of the carbonate of lime.

" If any minute proportion of alumina should, from peculiar circumstances, be dissolved by the acid, it will be found in the precipitate with the carbonate of lime, and it may be separated from it by boiling it for a few minutes with soap lye, sufficient to cover the solid matter; this substance dissolves alumina, without acting upon carbonate of lime.

" Should the finely-divided soil be sufficiently calcareous to effervesce very strongly with acids, a very simple method may be adopted for ascertaining the quantity of carbonate of lime, and one sufficiently accurate in all common cases.

" Carbonate of lime, in all its states, contains a determinate proportion of carbonic acid, *i. e.*, nearly 43 *per cent.*, so that when the quantity of this elastic fluid, given out by any soil during the solution of its calcareous matter in an acid is known, either in weight or measure, the quantity of carbonate of lime may be easily discovered.

" When the process by diminution of weight is employed, two parts of the acid and one part of the matter of the soil must be weighed in two separate bottles, and very slowly mixed together till the effervescence ceases; the difference between their weight before and after the experiment, denotes the quantity of carbonic acid lost; for every four grains and a quarter of which, 10 grains of carbonate of lime must be estimated.

" 6. After the calcareous parts of the soil have been acted upon by muriatic acid, the next process is to ascertain the quantity of finely-divided insoluble animal and vegetable matter that it contains.

" This may be done with sufficient precision, by strongly igniting it in a crucible over a common fire till no blackness remains in the mass. It should be often stirred with a metallic rod, so as to expose new surfaces continually to the air; the loss of weight that it undergoes denotes the quantity of the substance that it contains destructible by fire and air.

" It is not possible, without very refined and difficult experiments, to ascertain whether this substance is wholly animal or vegetable matter, or a mixture of both. When the smell emitted during the incineration is similar to that of burnt feathers, it is a certain indication of some substance either animal or analogous to animal matter; and a copious blue flame at the time of ignition, almost always denotes a considerable proportion of vegetable matter. In cases when it is necessary that the experiment should be very quickly performed, the destruction of the decomposable substances may be assisted by the agency of nitrate of ammonia, which at the time of ignition may be thrown gradually upon the heated mass in the quantity of 20 grains for every hundred of residual soil. It accelerates the dissipation of the animal and vegetable matter, which it causes to be converted into elastic fluids; and it is itself at the same time decomposed and lost.

"7. The substances remaining after the destruction of the vegetable and animal matter, are generally minute particles of earthy matter, containing usually alumina and silica, with combined oxide of iron or of manganese.

"To separate these from each other, the solid matter should be boiled for two or three hours with sulphuric acid, diluted with four times its weight of water; the quantity of the acid should be regulated by the quantity of solid residuum to be acted on, allowing for every hundred grains two drachms, or 120 grains, of acid,

"The substance remaining after the action of the acid, may be considered as siliceous: and it must be separated and its weight ascertained, after washing and drying in the usual manner.

"The alumina, and the oxide of iron and manganesum, if any exist, are all dissolved by the sulphuric acid; they may be separated by succinate of ammonia, added to excess, which throws down the oxide of iron; and by soap lye, which will dissolve the alumina, but not the oxide of manganese: the weights of the oxides ascertained after they have been heated to redness will denote their quantities.

"Should any magnesia and lime have escaped solution in the muriatic acid, they will be found in the sulphuric acid; this, however, is rarely the case; but the process for detecting them, and ascertaining their quantities, is the same in both instances.

"The method of analysis by sulphuric acid, is sufficiently precise for all usual experiments; but if very great accuracy be an object, dry carbonate of potassa must be employed as the agent, and the residuum of the incineration (6) must be heated red for a half hour, with four times its weight of this substance, in a crucible of silver, or of well baked porcelain. The mass obtained must be dissolved in muriatic acid, and the solution evaporated till it is nearly solid; distilled water must then be added, by which the oxide of iron and all the earths, except silica, will be dissolved in combination as muriates. The silica, after the usual process of lixiviation, must be heated red ; the other substances may be separated in the same manner as from the muriatic and sulphuric solutions.

" This process is the one usually employed by chemical philosophers for the analysis of stones.

" 8. If any saline matter, or soluble vegetable or animal matter is suspected in the soil, it will be found in the water of lixiviation used for separating the sand.

" This water must be evaporated to dryness in a proper dish, at a heat below its boiling point.

" If the solid matter obtained is of a brown colour and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be like that of burnt feathers, it contains animal or albuminous matter ; if it be white, crystalline, and not destructible by heat, it may be considered as principally saline matter.

" 9. Should sulphate or phosphate of lime be suspected in the entire soil, the detection of them requires a particular process upon it. A given weight of it, for instance, 400 grains, must be heated red for half an hour in a crucible, mixed with one-third of powdered charcoal. The mixture must be boiled for a quarter of an hour, in a half pint of water, and the fluid collected through the filter, and exposed for some days to the atmosphere in an open vessel. If any notable quantity of sulphate of lime (gypsum) existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion.

" Phosphate of lime, if any exist, may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil, in quantity more than sufficient to saturate the soluble earths; the solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphate of lime untouched.

" It would not fall within the limits assigned to this Lecture, to detail any processes for the detection of substances which may be accidentally mixed with the matters of soils. Other earths and metallic oxides are now and then found in them, but in quantities too minute to bear any relation to fertility or barrenness, and the search for them would make the analysis much more complicated without rendering it more useful.

" 10. When the examination of a soil is completed, the products should be numerically arranged, and their quantities added together, and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must, however, be noticed, that when phosphate or sulphate of lime are discovered by the independent process just described (9), a correction must be made for the general process, by subtracting a sum equal to their weight from the quantity of carbonate of lime, obtained by precipitation from the muriatic acid.

" In arranging the products, the form should be in the order of the experiments by which they were procured.

" Thus, I obtained from 400 grains of a good siliceous sandy soil, from a hop garden near Tunbridge, Kent,

		Grains.
Of water of absorption		19
— loose stones and gravel principally siliceous		53
— undecompounded vegetable fibres		14
— fine siliceous sand		212
Of minutely divided matter separated by agitation and filtration, and consisting of		
Carbonate of lime	19	
Carbonate of magnesia	3	
Matter destructible by heat, principally vegetable	15	
Silica	21	
Alumina	13	
Oxide of iron	5	
Soluble matter, principally common salt and vegetable extract	3	
Gypsum	2	
	—	81
Amount of all the products		379
Loss		21

" The loss in this analysis is not more than usually occurs, and it depends upon the impossibility of collecting the whole quantities of the different precipitates; and upon the presence of more moisture than is accounted for in the water of absorption, and which is lost in the different processes.

"When the experimenter is become acquainted with the use of the different instruments, the properties of the re-agents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid (7) may be omitted. In examining peat soils, he will principally have to attend to the operation by fire and air (8); and in the analysis of chalks and loams, he will often be able to omit the experiment by sulphuric acid (9).

"In the first trials that are made by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with: but in overcoming them, the most useful kind of practical knowledge will be obtained; and nothing is so instructive in experimental science, as the detection of mistakes. The correct analyst ought to be well grounded in general chemical information; but, perhaps, there is no better mode of gaining it, than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn the properties of the substances he is employing or acting upon; and his theoretical ideas will be more valuable in being connected with practical operations, and acquired for the purpose of discovery.

"Plants being possessed of no locomotive powers, can grow only in places where they are supplied with food; and the soil is necessary to their existence, both as affording them nourishment, and enabling them to fix themselves in such a manner as to obey those mechanical laws by which their radicles are kept below the surface, and their leaves exposed to the free atmosphere. As the systems of roots, branches, and leaves, are very different in different vegetables, so they flourish most in different soils; the plants that have bulbous roots require a looser and a lighter soil than such as have fibrous roots; and the plants possessing only short fibrous radicles demand a firmer soil than such as have tap roots, or extensive lateral roots.

" A good turnip soil from Holkham, Norfolk, afforded me eight parts out of nine siliceous sand; and the finely-divided matter consisted

Of carbonate of lime	63
— silica	15
— alumina	11
— oxide of iron	3
— vegetable and saline matter	5
— moisture	3

" I found the soil taken from a field at Sheffield-place, in Sussex, remarkable for producing flourishing oaks, to consist of six parts of sand, and one part of clay and finely-divided matter. And 100 parts of the entire soil, submitted to analysis, produced

	Parts.
Silica	54
Alumina	28
Carbonate of lime	3
Oxide of iron	5
Decomposing vegetable matter	4
Moisture and loss	3

" An excellent wheat soil, from the neighbourhood of West Drayton, Middlesex, gave three parts in five of siliceous sand; and the finely-divided matter consisted of

Carbonate of lime	28
Silica	32
Alumina	29
Animal or vegetable matter and moisture	11

"Of these soils the last was by far the most, and the first the least, coherent in texture. In all cases the constituent parts of the soil which give tenacity and coherence are the finely-divided matters; and they possess the power of giving those qualities in the highest degree when they contain much alumina. A small quantity of finely-divided matter is sufficient to fit a soil for the production of turnips and barley; and I have seen a tolerable crop of turnips on a soil containing 11 parts out of 12 sand. A much greater proportion of sand, however, always produces absolute sterility. The soil of Bagshot heath, which is entirely devoid of vegetable covering, contains less than $\frac{1}{25}$ of finely-divided matter. 400 parts of it, which had been heated red, afforded me 380 parts of coarse siliceous sand, nine parts of fine siliceous sand, and 11 parts of impalpable matter, which was a mixture of ferruginous clay, with carbonate of lime. Vegetable or animal matters, when finely-divided, not only give coherence, but likewise softness and penetrability; but neither they nor any other part of the soil must be in too great proportion; and a soil is unproductive if it consist entirely of impalpable matters.

"Pure alumina or silica, pure carbonate of lime, or carbonate of magnesia, are incapable of supporting healthy vegetation.

"No soil is fertile that contains as much as 19 parts out of 20 of any of the constituents that have been mentioned.

"It will be asked, are the pure earths in the soil merely active as mechanical or indirect chemical agents, or do they actually afford food to the plant? This is an important question; and not difficult of solution.

"The earths consist, as I have before stated, of metals united to oxygen; and these metals have not been decomposed; there is consequently no reason to suppose that the earths are convertible into the elements of organized compounds, into carbon, hydrogen, and azote.

"Plants have been made to grow in given quantities of earth. They consume very small portions only; and what is lost may be accounted for by the quantities found in their ashes; that is to say, it has not been converted into any new products.

"The carbonic acid united to lime or magnesia, if any stronger acid happens to be formed in the soil during the fermentation of vegetable matter which will disengage it from the earths, may be decomposed: but the earths themselves cannot be supposed convertible into other substances, by any process taking place in the soil.

"In all cases the ashes of plants contain some of the earths of the soil in which they grow; but these earths, as may be seen from the table of the ashes afforded by different plants given in the last Lecture*, never equal more than $\frac{1}{50}$ of the weight of the plant consumed.

---

* See Sir Humphry Davy's *Elements of Agricultural Chemistry*, 4to., p. 102.

"If they be considered as necessary to the vegetable, it is as giving hardness and firmness to its organization. Thus, it has been mentioned that wheat, oats, and many of the hollow grasses, have an epidermis principally of siliceous earth; the use of which seems to be to strengthen them, and defend them from the attacks of insects and parasitical plants.

"Many soils are popularly distinguished as *cold;* and the distinction, though at first view it may appear to be founded on prejudice, is really just.

"Some soils are much more heated by the rays of the sun, all other circumstances being equal, than others; and soils brought to the same degree of heat cool in different times, *i. e.*, some cool much faster than others.

"This property has been very little attended to in a philosophical point of view; yet it is of the highest importance in agriculture. In general, soils that consist principally of a stiff white clay are difficultly heated; and being usually very moist they retain their heat only for a short time. *Chalks* are similar in one respect, that they are difficultly heated; but being drier they retain their heat longer, less being consumed in causing the evaporation of their moisture.

"A black soil, containing much soft vegetable matter, is most heated by the sun and air; and the coloured soils, and the soils containing much carbonaceous matter, or ferruginous matter, exposed under equal circumstances to sun, acquire a much higher temperature than pale-coloured soils.

" When soils are perfectly dry, those that most readily become heated by the solar rays likewise cool most rapidly; but I have ascertained by experiment, that the darkest-coloured dry soil (that which contains abundance of animal or vegetable matter, substances which most facilitate the diminution of temperature,) when heated to the same degree, provided it be within the common limits of the effect of solar heat, will cool more slowly than a wet pale soil entirely composed of earthy matter.

" I found that a rich black mould, which contained nearly ¼ of vegetable matter, had its temperature increased in an hour from 65° to 88° by exposure to sunshine; whilst a chalk soil was heated only to 69° under the same circumstances. But the mould, removed into the shade, where the temperature was 62°, lost, in half an hour, 15°; whereas the chalk, under the same circumstances, had lost only 4°.

" Brown fertile soil, and a cold barren clay were each artificially heated to 88°, having been previously dried; they were then exposed in a temperature of 57°; in half an hour the dark soil was found to have lost 9° of heat; the clay had lost only 6°. An equal portion of the clay containing moisture, after being heated to 88°, was exposed in a temperature of 55°; in less than a quarter of an hour it was found to have gained the temperature of the room. The soils in all these experiments were placed in small tin-plate trays, two inches square and half an inch in depth; and the temperature ascertained by a delicate thermometer.

" Nothing can be more evident, than that the genial heat of the soil, particularly in spring, must be of the highest importance to the rising plant. And when the leaves are fully developed, the ground is shaded; and any injurious influence, which in the summer might be expected from too great a heat, entirely prevented: so that the temperature of the surface, when bare and exposed to the rays of the sun, affords at least one indication of the degrees of its fertility; and the thermometer may be sometimes a useful instrument to the purchaser or improver of lands.

" The moisture in the soil influences its temperature; and the manner in which it is distributed through, or combined with, the earthy materials, is of great importance in relation to the nutriment of the plant. If water is too strongly attracted by the earths, it will not be absorbed by the roots of the plants; if it is in too great quantity, or too loosely united to them, it tends to injure or destroy the fibrous parts of the roots.

" There are two states in which water seems to exist in the earths, and in animal and vegetable substances; in the first state it is united by chemical, in the other by cohesive, attraction.

" If pure solution of ammonia or potassa be poured into a solution of alum, alumina falls down combined with water; and the powder dried by exposure to air will afford more than half its weight of water by distillation; in this instance the water is united by chemical attraction. The moisture which wood, or muscular fibre, or gum, that have been heated to 212°, afford by distillation at a red heat, is likewise water, the elements of which were united in the substance by chemical combination.

" When pipe-clay, dried at the temperature of the atmosphere, is brought in contact with water, the fluid is rapidly absorbed; this is owing to cohesive attraction. Soils in general, vegetable, and animal substances, that have been dried at a heat below that of boiling water, increase in weight by exposure to air, owing to their absorbing water existing in the state of vapour in the air, in consequence of cohesive attraction.

"The water *chemically combined* amongst the elements of soils, unless in the case of the decomposition of animal or vegetable substances, cannot be absorbed by the roots of plants; but that *adhering* to the parts of the soil is in constant use in vegetation. Indeed there are few mixtures of the earths found in soils that contain any chemically combined water; water is expelled from the earths by most substances that combine with them. Thus, if a combination of lime and water be exposed to carbonic acid, the carbonic acid takes the place of water, and compounds of alumina and silica, or other compounds of the earths, do not chemically unite with water; and soils, as it has been stated, are formed either by earthy carbonates, or compounds of the pure earths and metallic oxides.

"When saline substances exist in soils, they may be united to water both chemically and mechanically; but they are always in too small a quantity to influence materially the relations of the soil to water.

"The power of the soil to absorb water by cohesive attraction, depends in great measure upon the state of division of its parts; the more divided they are, the greater is their absorbent power. The different constituent parts of soils likewise appear to act, even by cohesive attraction, with different degrees of energy. Thus vegetable substances seem to be more absorbent than animal substances; animal substances more so than compounds of alumina and silica; and compounds of alumina and silica more absorbent than carbonates of lime and magnesia; these differences may, however, possibly depend upon the differences in their state of division, and upon the surface exposed.

"The power of soils to absorb water from air, is much connected with fertility. When this power is great, the plant is supplied with moisture in dry seasons; and the effect of evaporation in the day is counteracted by the absorption of aqueous vapour from the atmosphere, by the interior parts of the soil during the day, and by both the exterior and interior during night.

"The stiff clays approaching to pipe-clays in their nature, which take up the greatest quantity of water when it is poured upon them in a fluid form, are not the soils which absorb most moisture from the atmosphere in dry weather. They cake, and present only a small surface to the air, and the vegetation on them is generally burnt up almost as readily as on sands.

"The soils that are most efficient in supplying the plant with water by atmospheric absorption, are those in which there is a due mixture of sand, finely-divided clay, and carbonate of lime, with some animal or vegetable matter; and which are so loose and light as to be freely permeable to the atmosphere. With respect to this quality, carbonate of lime and animal and vegetable matter are of great use in soils; they give absorbent power to the soil without giving it likewise tenacity; sand, which also destroys tenacity, on the contrary, gives little absorbent power.

" I have compared the absorbent powers of many soils with respect to atmospheric moisture, and I have always found it greatest in the most fertile soils; so that it affords one method of judging of the productiveness of land.

" 1000 parts of a celebrated soil from Ormiston, in East Lothian, which contained more than half its weight of finely-divided matter, of which 11 parts were carbonate of lime, and 9 parts vegetable matter, when dried at 212°, gained in an hour by exposure to air, saturated with moisture, at temperature 62°, 18 grains.

" 1000 parts of a very fertile soil from the banks of the river Parret, in Somersetshire, under the same circumstances, gained 16 grains.

" 1000 parts of a soil from Mersea, in Essex, worth 45 shillings an acre, gained 13 grains.

" 1000 grains of a fine sand from Essex, worth 28 shillings an acre, gained 11 grains.

" 1000 of a coarse sand, worth 15 shillings an acre, gained only eight grains.

" 1000 of the soil of Bagshot-heath gained only three grains.

" Water, and the decomposing animal and vegetable matter existing in the soil, constitute the true nourishment of plants; and as the earthy parts of the soil are useful in retaining water, so as to supply it in the proper proportions to the roots of the vegetables, so they are likewise efficacious in producing the proper distribution of the animal or vegetable matter; when equally mixed with it they prevent it from decomposing too rapidly; and by their means the soluble parts are supplied in proper proportions.

" Besides this agency, which may be considered as mechanical, there is another agency between soils and organizable matters, which may be regarded as chemical in its nature. The earths, and even the earthy carbonates, have a certain degree of chemical attraction for many of the principles of vegetable and animal substances. This is easily exemplified in the instance of alumina and oil; if an acid solution of alumina be mixed with a solution of soap, which consists of oily matter and potassa, the oil and the alumina will unite and form a white powder, which will sink to the bottom of the fluid.

" The extract from decomposing vegetable matter when boiled with pipe-clay or chalk, forms a combination by which the vegetable matter is rendered more difficult of decomposition and of solution. Pure silica and siliceous sands have little action of this kind; and the soils which contain the most alumina and carbonate of lime, are those which act with the greatest chemical energy in preserving manures. Such soils merit the appellation which is commonly given to them of rich soils; for the vegetable nourishment is long preserved in them, unless taken up by the organs of plants. Siliceous sands, on the contrary, deserve the term hungry, which is commonly applied to them; for the vegetable and animal matters they contain not being attracted by the earthy constituent parts of the soil, are more liable to be decomposed by the action of the atmosphere, or carried off from them by water.

"In most of the black and brown rich vegetable moulds, the earths seem to be in combination with a peculiar extractive matter, afforded during the decomposition of vegetables: this is slowly taken up, or attracted from the earths by water, and appears to constitute a prime cause of the fertility of the soil.

"The standard of fertility of soils for different plants must vary with the climate; and must be particularly influenced by the quantity of rain.

"The power of soils to absorb moisture ought to be much greater in warm or dry countries, than in cold and moist ones; and the quantity of clay, or vegetable or animal matter they contain, greater. Soils also on declivities ought to be more absorbent than in plains or in the bottom of valleys. Their productiveness likewise is influenced by the nature of the subsoil or the stratum on which they rest.

"When soils are immediately situated upon a bed of rock or stone, they are much sooner rendered dry by evaporation, than where the subsoil is of clay or marl; and a prime cause of the great fertility of the land in the moist climate of Ireland, is the proximity of the rocky strata to the soil.

"A clayey subsoil will sometimes be of material advantage to a sandy soil; and in this case it will retain moisture in such a manner as to be capable of supplying that lost by the earth above, in consequence of evaporation, or the consumption of it by plants.

"A sandy or gravelly subsoil, often corrects the imperfections of too great a degree of absorbent power in the true soil.

" In calcareous countries, where the surface is a species of marl, the soil is often found only a few inches above the limestone; and its fertility is not impaired by the proximity of the rock; though in a less absorbent soil, this situation would occasion barrenness; and the sandstone and limestone hills in Derbyshire and North Wales may be easily distinguished at a distance in summer by the different tints of the vegetation. The grass on the sandstone hills usually appears brown and burnt up; that on the limestone hills, flourishing and green.

" In devoting the different parts of an estate to the necessary crops, it is perfectly evident from what has been said, that no general principle can be laid down, except when all the circumstances of the nature, composition, and situation of the soil and subsoil are known.

" The methods of cultivation likewise must be different for different soils. The same practice which will be excellent in one case may be destructive in another.

" Deep ploughing may be a very profitable practice in a rich thick soil; and in a fertile shallow soil, situated upon cold clay or sandy subsoil, it may be extremely prejudicial.

" In a moist climate where the quantity of rain that falls annually equals from 40 to 60 inches, as in Lancashire, Cornwall, and some parts of Ireland, a siliceous sandy soil is much more productive than in dry districts; and in such situations wheat and beans will require a less coherent and absorbent soil than in drier situations; and plants, having bulbous roots, will flourish in a soil containing as much as 14 parts of out 15 of sand.

"Even the exhausting powers of crops will be influenced by like circumstances. In cases where plants cannot absorb sufficient moisture, they must take up more manure. And in Ireland, Cornwall, and the western Highlands of Scotland, corn will exhaust less than in dry inland situations. Oats, particularly in dry climates, are impoverishing in a much higher degree than in moist ones."

APPENDIX,

CONTAINING

EQUIVALENT NUMBERS OF VEGETABLE AND ANIMAL PRODUCTS,
AND THEIR COMBINATIONS.

BIBLIOTHECA · BODLEIANA

TABULAR VIEW

OF THE

NT NUMBERS OF VEGETABLE AND ANIMAL PRODUCTS, AND THEIR COMBINATIONS.

SUBSTANCES	Equivalent Number	COMPOSITION
	85	
mmate of lead	274.5	170 gum. + 104.5 ox. of lead.
R	75	
arate of lead	179.5	75 sugar + 104.5 ox. of lead.
CH	135	
nilate of lead	374.5	270 starch + 104.5 ox. of lead.
NIN	200	
ate of lead	304.5	200 tannin + 104.5 ox. of lead.
:	140	
)		
PHORIC ACID?		
INIC ACID	47	
inate of ammonia	63	47 S. A. + 16 ammon.
——— potassa	92	47 S. A. + 45 P.
——— soda	76.5	47 S. A. + 29.5 S.
——— lime	73.5	47 S. A. + 26.5 L.

Equivalent Numbers, &c. (continued.)

SUBSTANCES.	Equivalent Number.	COMPOSITION.
XVI. OXALIC ACID	35.5	
Oxalate of ammonia	51.5	35.5 O. A. + 16 Am.
———— potassa	80.5	35.5 O. A. + 45 P.
———— soda	65	35.5 O. A. + 29.5 S.
———— lime	62	35.5 O. A. + 26.5 L.
———— baryta	108	35.5 O. A. + 72.5 B.
———— strontia	87.5	35.5 O. A. + 52 S.
———— magnesia	54	35.5 O. A. + 18.5 M.
———— manganese	71.5	35.5 O. A. + 36 O. M.
———— iron	69	35.5 O. A. + 33.5 O. I.
———— zince	76	35.5 O. A. + 40.5 O. Z.
———— tin	98.5	35.5. O. A. + 63 O. T.
———— copper	146	71 O. A. + 75 Perox. C.
———————— and ammonia	197.5	146 Ox. Cop. + 51.5 Oxal.am
———————— and potassa	226.5	146 Ox. Cop. + 80.5 Ox. Pot.
———————— and soda	211	146 Ox. Cop. + 65 Ox. Sod.
———— lead	140	35.5 O. A. + 104.5 O. L.
———— antimony	88	35.5 O. A. + 52.5 O. Ant.
———— bismuth	129.5	35.5 O. A. + 74 O. B.
———— cobalt	73.5	35.5 O. A. + 38 O. C.
———— uranium ?		
———— nickel	71	35.5 O. A. + 35.5. O. N.
———— mercury	233	35.5 O. A. + 197.5 O. M.
———— silver	145.5	35.5 O. A. + 110 O. S.
XVII. CITRIC ACID	55.5	

Equivalent Numbers, &c. (continued.)

SUBSTANCES.	Equivalent Number.	COMPOSITION.
Citrate of ammonia............	71.5	55.5 C. A. + 16 Am.
——— potassa.............	100.5	55.5 C. A. + 45 P.
——— soda	85	55.5 C. A. + 29.5 S.
——— lime	82	55.5 C. A. + 26.5 L.
——— baryta.............	128	55.5 C. A. + 72.5 B.
——— strontia	107.5	55.5 C. A. + 52 S.
——— magnesia	74	55.5 C. A. + 18.5 M.
——— manganese..........	91.5	55.5 C. A. + 36 O. M.
——— iron	89	55.5 C. A. + 33.5 O. I.
——— zinc...............	96	55.5 C. A. + 40.5 O. Z.
——— tin	118.5	55.5 C. A. + 63 O. T.
——— copper	186	111 C. A. + 75 per ox. C.
——— lead	160	55.5 C. A. + 104.5 O. L.
——— antimony?		
——— bismuth	129.5	55.5 C. A. + 74 O. B.
——— cobalt..............	93.5	55.5 C. A. + 38 O. C.
——— uranium?		
——— nickel..............	90	55.5 C. A. + 35.5 O. N.
——— mercury	253	55.5 C. A. + 197.5 O. M.
——— silver	165.5	55.5 C. A. + 110 O. S.
I. MALIC ACID	66	
X. GALLIC ACID	60	
X. BENZOIC ACID	112	
Benzoate of ammonia	128	112 B. A. + 16 Amm.
——— potassa	157	112 B. A. + 45 P.

Equivalent Numbers, &c. (continued.)

SUBSTANCES.	Equivalent Number.	COMPOSITI
Benzoate of soda	141.5	112 B. A. + 29.5 S.
—— lime	138.5	112 B. A. + 26.5 L.
—— baryta	184.5	112 B. A. + 72.5 B.
—— lead	216.5	112 B. A. + 104.5
XXI. ACETIC ACID	48	
Acetate of ammonia	64	48 A. A. + 16 Amm
—— potassa	93	48 A. A. + 45 P.
—— soda	77	48 A. A. + 29.5 S.
—— lime	74.5	48 A. A. + 26.5 L.
—— baryta	120.5	48 A. A. + 72.5 B.
—— strontia	100	48 A. A. + 52 S.
—— magnesia	66.5	48 A. A. + 18.5 M.
—— manganese	84	48 A. A. + 36 O. M.
—— iron	81.5	48 A. A. + 33.5 O. I
—— zinc	88.5	48 A. A. + 40.5 O.
—— tin	111	48 A. A. + 63 O. T.
—— copper	171	96 A. A. + 75 Perox
—— lead	152.5	48 A. A. + 104.5 O.
—— bismuth	122	48 A. A. + 74 O. B.
—— mercury	245.5	48 A. A. + 197.5 O.
—— silver	158	48 A. A. + 110 O. S.
—— alumina?		
XXII. FORMIC ACID? ....Probably a compound of Malic and Acetic		
XXIII. URIC ACID?	33	

INDEX.

CA·BODLEIANA

INDEX.

S *OF HEAT*, i. 299
, *Florentine*, their experi-
nts on thermometers, i. 88
ducting powers of metals,
i. 93
expansion of water by cold,
i. 91
radiation of cold, i. 93
radiation, reflection, and
refraction of heat, i. 93
ciences, *Royal*, i. 54
rom mapple juice)
mine, iii. 165, 170
, iii. 164, 350
, iii. 169
ii. 165, 350
, iii. 169, 350
ii. 169
ii. 169
ii. 162, 166, 350
165, 350
162, 163, 167, 350
d as a test, i. 145
96; iii. 165, 350
, iii. 165, 350
se, iii. 165, 350
, iii. 169, 350
i. 169
ii. 164, 350
iii. 113

Acetate of silver, iii. 170. 350
soda, iii. 162, 164, 350
strontia, iii. 165, 350
tin, iii. 166, 350
uranium, iii. 169
zinc, iii. 166, 350
Acetic acid, iii. 161, 350
procured, iii. 162
analysis of, iii. 163
from wood, iii. 162
its properties, iii. 162
ether
Acetous fermentation, iii. 160
Acid, defined by Bergman, i. 152
aceric, (from mapple juice)
acetic, iii. 161, 350
acetous, iii. 161
aërial, i. 152, 422
air, vitriolic, i. 136, 336
amniotic (from the amnios of the cow)
antimonic, ii. 175
antimonious, ii. 175
arsenic, i. 168; ii. 206, 531
arsenious, i. 168; ii. 203, 531
benzoic, i. 170; iii. 103, 349
boletic, iii. 107, 126
boracic, i. 54, 453, 470
camphoric, iii. 62
carbonic, i. 116, 152, 177, 422, 469

Acid, caseic (from cheese)
  cetic, iii. 211
  chloric, i. 322, 464
  chloriodic, i. 325, 464
  chlorous, i. 322
  chloro-carbonic, i. 421, 469
  chloro-cyanic, i. 448, 470
  chromic, ii. 221, 534
  citric, i. 170; iii. 93, 348
  columbic, ii. 230, 535
  cyanic, i. 447
  dephlogisticated muriatic (chlorine) i. 167, 318
  ellagic, iii. 108
  ferro-chyazic, ii. 125
  ferro-prussic, ii. 125
  ferruretted chyazic, ii. 125
  fluoboric, ii. 75, 512
  fluoric, ii. 73, 74, 512
  fluoric, subsilicated, ii. 305
  fluosilicic, ii. 305
  formic (from ants), iii. 350
  fungic, iii. 108, 126
  gallic, iii. 98, 349
  hydriodic, i. 345, 465
  hydrochloric, i. 341
  hydrocyanic, i. 449, 470
  —— how prepared, i. 450
  —— used in medicine, i. 450
  hydrofluoric, ii. 73, 74, 512
  hydrophosphorous, i. 404, 468
  hydrophtoric, ii. 74
  hydrosulphuric, i. 398
  hydrothionic, i. 398
  hyponitrous, i. 350
  hyposulphuric, i. 387; ii. 84
  hyposulphurous, i. 387, 466
  hypophosphorous, i. 404, 467
  igasuric, iii. 73
  iodic, i. 321, 464
  iodosulphuric, i. 396
  kinic, iii. 108
  krameric, iii. 108
  laccic, iii. 65, 66
Acid, lactic, i. 169; iii. 185
  lampic, iii. 154
  lithic, iii. 192
  malic, iii. 97, 349
  manganesic, ii. 106
  margaritic, iii. 210
  meconic, iii. 70, 346
  mellitic, iii. 77
  menispermic (from menisperm coculus)
  molybdic, ii. 218, 533
  molybdous, ii. 218, 533
  moroxylic, iii. 107
  mucic, iii. 184
  mucous, iii. 19
  muriatic, i. 47, 220, 341, 465
  —— dephlogisticated, i. 318, 16
  nanceic, (zumic) iii. 108
  nitric, i. 156, 352, 465
  nitroleucic, iii. 207
  nitro-muriatic, i. 357
  nitro-saccharine, iii. 204
  nitro-sulphuric, ii. 278
  nitrous, i. 351, 465
  œnothionic, iii. 153
  oleic, iii. 210
  oxalic, iii. 86, 344
  oxiodic, i. 324, 464
  oxychloric, i. 322, 464
  oxymuriatic, i. 167, 318
  perchloric, i. 322, 464
  perlate (acidulous phosphate soda)
  pernitrous, i. 350
  phosphatic, i. 407
  phosphoric, i. 404, 468
  phosphorous, i. 404, 468
  prussic, i. 171, 449, 470
  —— preparation of, i. 450
  purpuric, iii. 193
  pyroacetic, iii. 164
  pyroligneous, iii. 162
  pyromucous, iii. 20
  pyrotartarous, iii. 79

mic, (from rhubarb)
lactic, iii. 19, 184
c (from fat)
, ii. 202, 441
ed fluoric, ii. 305
, iii. 97
e, ii. 143
, ii. 175
s, ii. 175
c, iii. 43
ic, iii. 66, 345
ar, iii. 86, 348
-cyanic, i. 451, 470
vinous, iii. 154
uretted chyazic, i. 451
uric, i. 389, 467
urous, i. 136, 388, 466
ic, iii. 78, 346
c, ii. 201
ic, ii. 225, 226, 535
ii. 192, 350
, iii. 108
substances, simple, i. 326
of, i. 464
principle, i. 309
tallic, ii. 13
of the blow-pipe on, ii. 341
nclature of, i. 310
th of, ascertained, ii. 357
of, i. 142, 215
able, iii. 78
, ii. 257
ceticum, iii. 161
icum, iii. 103
ticum, i. 341
um, i. 352
uricum, i. 389
iii. 82
, ii. 317
ne spar, ii. 312
, iii. 175
ral, iii. 76
colours, iii. 47
iii. 263

Aërial acid, i. 152
    tests of, i. 143
    its elective attractions, i. 153
Aëriform fluids, Lavoisier on, i. 174
Aërolites, ii. 236
Æther, i. 170; iii. 147
Aetites, ii. 114
Affinity, i. 213
    aggregative, i. 192
    chemical, i. 213
    —— Bergman on, i. 79, 149
    —— Berthollet on, i. 81
    —— Geoffroy on, i. 78
    —— Mayow on, i. 73
    —— Newton on, i. 75
    complex, i. 218
    elective, i. 216
    heterogeneous, i. 213
    homogeneous, i. 192
    simple, i. 217
    —— tables of, i. 216
Agate, ii. 307
Ages of metals, iii. 307
Aggregation, attraction of, i. 192
    its effect on chemical attraction, i. 216
Agricola, on analysis, i. 148
    on bismuth, ii. 3
Agriculture, application of chemistry to, iii. 316
Aikin on acetate of zinc, iii. 166
    on analysis of cerite, ii. 433
    — arsenical pyrites, ii. 445
    — leather, iii. 206
Air, a ponderous body, i. 370
    weight of, i. 373, 465
    expansion of by heat, i. 226
    physical properties of, i. 370
    opinions of Boerhaave on, i. 112
    Priestley's remarks on, i. 128, 132
    purification of, by vegetation, i. 132
    effect of, on crystallization, i. 196
    conduction of heat by, i. 237

Air, the same in high regions as at the earth's surface, i. 160
ignition of, i. 305
of water, i. 339
analysis of, i. 160, 163, 175, 380
rarefied, a conductor of electricity, i. 254
empyreal of Scheele, i. 163
fixed, i. 44, 116, 152, 177, 422
balloon, i. 330
bladders of fish, iii. 225
pump, i. 61, 372
pistol, i. 327
thermometer, i. 231
—— described by Van Helmont, i. 87
Aix-la-Chapelle waters, ii. 502
Alabaster, ii. 67; iii. 290
Albert of Cologne, i. 12
Albertus Magnus, i. 12
Albumen, iii. 176, 177
its properties, iii. 178
analysis of, iii. 179
animal, iii. 178
of urine, iii. 194
vegetable, iii. 36
its conversion into gelatine, iii. 179
Alburnum, iii. 3
Alcali, silicated, ii. 298
volatile, i. 361
Alcalies, properties of, i. 361; ii. 32, 48
decomposition of, i. 363; ii. 28
action of, on fixed oils, iii. 57
—— metals, ii. 16
fixed, ii. 13, 30, 48
mineral, ii. 48
vegetable, ii. 32, 43
their use in glass-making, ii. 298
—— as tests, i. 143
strength of, ascertained, ii. 44, 354
tests of the, i. 142, 144, 215
their alcoholic solutions, iii. 145
Alcalimeter, ii. 354
Alcalimetry, ii. 44, 354
Alcaline earths, ii. 13, 78
baryta, ii. 77
lime, ii. 60
magnesia, ii. 95
strontia, ii. 89
gas described by Priestley,
Alchymical arrangement, i. 15
Alchymists, elements of the, i. 4
their notion of combustion, i
Alchymists, their deceits, i. 18
Lord Bacon's character of t
Albert of Cologne, i. 12
Albertus Magnus, i. 12
Arnold of Villa Nova, i. 13
Artiphius, i. 9
Basil Valentine, i. 28
Digby, Sir Kenelm, i. 22
Elias Ashmole, i. 23
Geber, i. 8
Helvetius, Dr., i. 18
Hermes, Trismegistus, i. 6
Nicholas Flammel, i. 13
Norton, Thomas, i. 24
Paracelsus, i. 39
Price, Dr., i. 25
Raymond Lully, i. 13
Ripley, George, i. 1
Salmon, Dr., i. 14
Van Helmont, i. 17, 41
Woulfe, Peter, i. 25
Alchymy, history of, i. 6
Alcohol, iii. 131
prepared, iii. 135
its properties, iii. 135
— analysis, iii. 146
— decomposition, iii. 145
— combustion, iii. 144
— composition, iii. 146
— refraction, i. 288
— expansion by heat, i. 225
action of acids on, iii. 146, 14
159
—— alcalis on, iii. 145
inflamed by electric spark, i.

Alcohol, not produced by distillation, iii. 131
  latent heat in the vapour of, i. 245
  mixtures of water with, iii. 136
  mode of ascertaining its purity, iii. 144
  apparatus for mixing it with water, iii. 136
  used as a test, i. 145
  solvent powers of, iii. 145
  table of, in wines, iii. 132
  —— its specific gravity when diluted, iii. 138
  —— strength of, iii. 138
  thermometer, i. 230
  tinged flame of, iii. 145
  vapour of, iii. 136
  of sulphur (sulphuret of carbon), i. 451, 470
Alcoholic solution of caustic potassa, iii. 145
Ale, iii. 135
Alembic, i. 323
Algarotti's powder, ii. 177
Allanite, ii. 197
  analysis of, ii. 434
Allen on the combustion of the diamond, i. 425
  respiration, iii. 223
Alloy, fusible, ii. 24
Alloys, ii. 22
  of metals, how formed, ii. 23
  qualities of the metals altered in, ii. 23
  are chemical compounds, ii. 23
  characters of, ii. 23
  oxidability of, ii. 25
  specific gravity of, ii. 24
  of antimony, ii. 182
  — arsenic, ii. 215
  — bismuth, ii. 186
  — copper, ii. 160
  — gold, ii. 287
  — iron, ii. 127, 236
Alloys of lead, ii. 171
  of mercury, ii. 260
  — nickel, ii. 236
  — platinum, ii. 295
  — potassium and sodium, ii. 56
  — rhodium, ii. 265
  — silver, ii. 280
  — steel, ii. 133, 265, 280, 241, 308
  — tin, ii. 127, 146
  — zinc, ii. 139
Alluvial formations, iii. 242, 295
Almonds, iii. 119
  oil of, iii. 119
Alum, i. 210; ii. 309; iii. 312
  preparation of, ii. 309
  properties of, ii. 309
  composition of, ii. 310
  applied in the arts, ii. 311
  of potash, ii. 309
  — soda, ii. 311
  — ammonia
  burnt, ii. 310
  cubic, ii. 310
  dried, ii. 310
  roach, ii. 310
Alumen, ustum, ii. 310
Alumina, ii. 308
  native, ii. 313; iii. 313
  obtained, ii. 309
  constitutes the gems, ii. 308
  properties of, ii. 309
  tests of, ii. 340
  appearance of, before the blowpipe, ii. 340
  detected in mineral waters, ii. 500
  acetate of, iii. 170
  benzoate of, iii. 106
  hydrate of, ii. 309
  oxalate of, iii. 92
  salts of, ii. 311
  sulphate of potash and, ii. 309
  —— soda and, ii. 311
  tartrate of, iii. 86
  use in dyeing, iii. 50

Aluminous minerals, ii. 312
analysis of, ii. 469
Alumium, ii. 308
and steel, ii. 308
Amalgam, electrical, i. 256
of ammonia, ii. 261
— calcium, ii. 60
— copper, ii. 260
— gold, ii. 260, 291
— magnesium, ii. 95
— potassium, ii. 260
— silver, ii. 260, 281
— zinc, ii. 260
Amalgams, ii. 260
Amalgamation of silver ores, ii. 268
Amazon-stone, iii. 253
Amber, iii. 66
acid of, iii. 66
Ambergris, iii. 211
Amethyst, ii. 307
Amianthus, ii. 318
Amilate of lead, iii. 31, 345
Ammonia, i. 361, 466; iii. 173
pure, discovered by Priestley, i. 136
preparation of, i. 361
qualities of, i. 361
its absorption by charcoal, i. 419
— —— chlorides, ii. 63, 271
— acetate, iii. 164, 346
— action on metals, ii. 16
— amalgam, ii. 261
— analysis, i. 363
— antimoniate, ii. 176
— arseniate, ii. 207, 532
— arsenite, ii. 205
— benzoate, iii. 104, 345
— bi-carbonate, i. 432, 469
— bi-tartrate, iii. 79
— borate, i. 454, 470
— camphorate, iii. 63
— carbonate, i. 431, 469
— chlorate, i. 365, 466
— chromate, ii. 223, 534
— citrate, iii. 94, 349
Ammonia, its combustion, i. 361,
ii. 271
— composition, i. 364
— decomposition, i. 363, 364
— density when in solution, i.
— ferrocyanate, ii. 125
— fluate, ii. 75
— fluoborate, ii. 76
— hydriodate, i. 367, 466
— hydrofluate, ii. 75
— hydrosulphuret, i. 399, 467
— —— used as a test, i. 400; ii.
— hypophosphite, i. 407
— hyposulphite, i. 466
— iodate, i. 365
— liquor, i. 362
— meconiate, iii. 71
— metallization, ii. 261
— molybdate, ii. 219, 534
— muriate, i. 47, 366, 466
— —— how procured, i. 366
— nitrate, i. 367, 466
— oxalate, iii. 88, 348
— —— with copper, iii. 90
— —— a test for lime, iii. 88
— phosphate, i. 407, 468; iii. 19
— phosphite, i. 407, 468
— refraction, i. 268
— sesquicarbonate, i. 432
— silico-fluate, ii. 306
— solution in water, i. 361, 466
— —— properties of, i. 362
— —— specific gravity of, i. 361
— —— latent heat in the vapour
i. 245
— —— of copper, ii. 154
— —— of nickel, ii. 233
— specific gravity, i. 361
— subcarbonate, i. 432
— succinate, iii. 67, 345
— sulphate, i. 47, 396, 467
— sulphite, i. 389, 467
— supersulphate, i. 397
— synthesis, i. 365

Ammonia, its tartrate, iii. 79, 342
its tartrate with potassa, iii. 81, 346
— tungstate, ii. 227
— urate, iii. 193, 201
— use as a test, i. 143
and chlorine, i. 365, ii. 271
— muriatic acid, i 366
— nitric acid, i. 367
and oxygen burn, i. 362
— perchloride of phosphorus, i. 409
Ammoniacal salts, i. 365
Ammoniaco-magnesian sulphate, ii. 99, 516
phosphate, ii. 100, 516; iii. 194
Ammoniacum, iii. 66
Ammoniæ subcarbonas, i. 432
procured by Glauber, i. 47
Ammonio-carbonate of silver, ii. 279
muriate of mercury, ii. 251
—— platinum, ii. 293
nitrate of copper, ii. 153
—— mercury, ii. 253
—— magnesia, ii. 97, 516
—— nickel, ii. 234
phosphate of magnesia, ii. 100, 516; iii. 194
—— soda, ii. 53, 509; iii. 194
sulphate of magnesia, ii. 99, 516
—— nickel, ii. 234
—— mercury, ii. 258
—— potassa, ii. 42, 506
—— soda, ii. 52, 508
tartrate of potassa, iii. 81
Ammonium, ii. 261
Ammoniuret of cobalt, ii. 190
copper, ii. 154
nickel, ii. 233
silver, ii. 540
zinc, ii. 135
Ammoniurets, ii. 17
Amniotic acid (from the amnios of the cow)
Ampere on Phtore, ii. 73
Amygdaloid, iii. 298
Amylate of lead, iii. 31, 345
Analcime, ii. 313
Analysis, i. 222
general directions for conducting processes of, ii. 332
proximate, i. 223
ultimate, i. 223
vegetable, iii. 10
of air, i. 163, 175, 380
Analysis of alkaline minerals, ii. 359
of allanite, ii. 434
— alloys, ii. 162, 171, 183
— aluminous compounds, ii. 469
— arragonite, ii. 376
— arseniate of copper, ii. 446
— —— lead, ii. 447
— —— lime, ii. 447
— arsenical pyrites, ii. 445
— arsenical cobalt, ii. 425
— bismuthic silver, ii. 460
— black ore of tellurium, ii. 438
— —— sulphuret of copper, ii. 405
— blende, ii. 391, 393
— boracic acid minerals, ii. 471
— bournonite, ii. 418
— calamine, ii. 394
— carbonate of copper, ii. 410
— —— lead, ii. 414
— —— lime, ii. 370
— —— magnesia, ii. 378
— cerite, ii. 432
— chloride of copper, ii. 404
— —— iron, ii. 384
— —— tin, ii. 398
— —— zinc, ii. 390
— chromate of iron, ii. 452
— —— lead, ii. 451
— cinnabar, ii. 459
— cobalt, impure, ii. 424
— columbite, ii. 454
— compounds of alumina, ii. 469
— —— antimony, ii. 415
— —— arsenic, ii. 444
— —— barium, ii. 374
— —— bismuth, ii. 421

Analysis of, compounds of cadmium, ii. 402
— —— calcium, ii. 370
— —— cerium, ii. 432
— —— chromium, ii. 451
— —— cobalt, ii. 424
— —— columbium, ii. 454
— —— copper, ii. 404
— —— glucinum, ii. 479
— —— gold, ii. 467
— —— iron, ii. 383
— —— lead, ii. 412
— —— lithium, ii. 368
— —— magnesium, ii. 376
— —— manganese, ii. 381
— —— mercury, ii. 458
— —— molybdenum, ii. 450
— —— nickel, ii. 455
— —— platinum, ii. 468
— —— selenium, ii. 440
— —— silica, ii. 469
— —— silver, ii. 460
— —— sodium, ii. 361
— —— strontium, ii. 376
— —— tellurium, ii. 434
— —— thorinum, ii. 482
— —— tin, ii. 396
— —— titanium, ii. 431
— —— tungsten, ii. 452
— —— uranium, ii. 428
— —— yttrium, ii. 482
— —— zinc, ii. 389
— —— zirconia, ii. 478
— emerald, ii. 479
— ferro-arsenical sulphuret of copper, ii. 406
— fluor spar, ii. 373
— fluoric minerals, ii. 470
— galena, ii. 412
— graphic ore, ii. 436
— green tourmaline, ii. 471
— grey ore of tellurium, ii. 436
— gunpowder, ii. 353
— harmotome, ii. 375
— indigo, iii. 49

Analysis of kryolite, ii. 477
— leucite, ii. 359
— light, i. 292
— limestones, ii. 370 ; iii. 322
— magnesian limestones, ii. 371
— —— minerals, ii. 378
— magnetic pyrites, ii. 384
— marles, iii. 322
— menachanite, ii. 431
— minerals in general, ii. 332
— mineral waters, i. 146 ; ii. 484,
— molybdate of lead, ii. 450
— murio-carbonate of lead, ii. 4
— —— sulphate of mercury, ii.
— native antimony, ii. 416
— —— oxides of iron, ii. 383
— —— phosphate of copper, ii.
— —— tellurium, ii. 435
— needle ore of Siberia, ii. 421
— ores, i. 148
— ores of iron, ii, 383
— —— manganese, ii. 381
— —— nickel, ii. 455
— oxide of bismuth, ii. 423
— —— zinc, ii. 389
— pechblende, ii. 429
— pharmacolite, ii. 447
— pitch ore of uranium, ii. 429
— phosphate of iron, ii. 387
— potassium compounds, ii. 35
— red ore of antimony, ii. 417
— salts of cadmium, ii. 403
— salts of lead, ii. 413
— selenium ore, ii. 442
— serpentine, ii. 379
— siliceous compounds, ii. 469
— sodalite, ii. 363
— soils, iii. 316
— spinelle, ii. 472
— sulphate of iron, ii. 386
— —— lead, ii. 412
— —— lime, ii. 371
— —— magnesia, ii. 376
— —— nickel, ii. 457

Analysis of sulphate of soda, ii. 361
— sulphuret of antimony, ii. 416
— —— arsenic and iron, ii. 446
— —— bismuth, ii. 421
— —— iron, ii. 384
— —— lead, antimony, and copper, ii. 418
— —— lead, copper, and bismuth, ii. 421
— —— molybdenum, ii. 450
— —— zinc, ii. 391
— tin ores, ii. 396
— titanite, ii. 431
— tourmaline, green, ii. 471
— tungstate of lime, ii. 452
— uranite, ii. 429
— vegetable substances, iii. 10
— white cobalt glance, ii. 425
— —— ore of antimony, ii. 416
— —— silver ore, ii. 463
— wolfram, ii. 454
— yellow ore of tellurium, ii. 436
— zircons, ii. 478
Analytical chemistry, history of, i. 141
improved by Bergman, i. 140
processes of, ii. 332, 351
Anatase, ii. 195
Angles of crystals, measurement of, i. 199
Anhydrite, ii. 67; iii. 290
Anhydrous gypsum, ii. 67
Animal jelly, iii. 203
oils, iii. 208
oil, Dippel's, iii. 173
substances, iii. 172
—— primary, iii. 172
—— complicated, iii. 175
—— analysis of, i. 177
—— putrefaction of, iii. 173
principles, ultimate, iii. 172
—— proximate, iii. 175
functions, iii. 216
charcoal, iii. 173
heat, iii. 225
electricity, i. 262
Animal chemistry, iii. 172
Animals, effect of light on, i. 179
killed by electricity, i. 268
Annealing of glass, ii. 302
Annotta, iii. 121
Antidote for baryta as a poison, ii. 89
Antients, metals known to the, ii. 3
Antimonane (chloride of antimony), ii. 176
Antimonial powder, ii. 180
Antimonialis pulvis, ii. 180
Antimoniate of ammonia, ii. 176
potassa, ii. 176
Antimonic acid, ii. 175, 176
Antimonii oxydum, ii. 173
sulphuretum precipitatum, ii. 179
Antimonious acid, ii. 175
Antimonium tartarizatum, iii. 84
Antimony, ii. 3, 172, 527
acetate of, iii. 169
acidifiable, ii. 176
action of acids on, ii. 177
alloys of, ii. 182
analysis of ores of, ii. 415
argentine flowers of, ii. 174
arseniate of, ii. 210
Basil Valentine on, i. 38
burns in chlorine, i. 216; ii. 17
butter of, ii. 176
chloride of, ii. 176, 527
combustion of, ii. 173
compounds of, analyzed, ii. 415
crocus of, ii. 178
diaphoretic, ii. 174
flowers of, ii. 174
golden sulphur of, ii. 179
glass of, ii. 178
hydrosulphuretted oxide of, ii. 179
iodide of, ii. 177, 527
liver of, ii. 178
native oxide of, ii. 172
nitrate of, ii. 177
obtained pure, ii. 172
ores of, ii. 172, 415
oxalate, iii. 348
oxides of, ii. 173, 345, 527

Antimony, peroxide, ii. 174, 527
    phosphuret of, ii. 180, 528
    phosphate, ii. 528
    precipitated sulphuret, ii. 179
    properties of, ii. 173
    protoxide of, ii. 173, 527
    saffron of, ii. 178
    salts of, ii. 527
    sulphate of, ii. 178, 528
    sulphuret of, ii. 178, 527
    ——— analyzed, ii. 416
    sulphuretted oxide of, ii. 179
    tartrate of, iii. 347
    tartrate of, with potassa, iii. 84, 347
    tartarised, iii. 84, 347
    tests of, ii. 182, 345, 527
Antiputrefactives, iii. 174
Apothecaries' Hall, laboratories of, heated by steam, i. 246
Apparatus, i. xiii. 312,
    chemical, improved by Glauber, i. 51
    Lavoisier on, i. 174, 181
    for coal gas, i. xiv. 439,
    — combustion of the diamond, i. 423
    — examination of mineral waters, ii. 485
    hydro-pneumatic, i. 312
    Woulfe's, i. 343
    ——— contrived by Glauber, i. 51
Apatite, ii, 70
Apophyllite, ii. 313
Aquafortis, i. 355
    history of, i. 31
Aqua-regia, i. 357
Aqua-saphirina, ii. 154
Aquatic plants evolve oxygen, i. 134
Aqueous vapour in the atmosphere, i. 384
Aquila alba, ii. 245
Aquila mitigata, ii. 245
Arago on refractive powers, i. 288
    polarization, i. 291
Arbor Dianæ, ii. 274
Arcanum duplicatum, ii. 41
Archil, iii. 125
Ardent spirit, iii. 131
Areometer (hydrometer) iii. 129
Arfwedson on lithia, ii. 57
    on green tourmaline, ii. 471
    on petalite, ii. 368
Argal crude (tartar) iii. 80
Argentane, ii. 270, (chloride of silver)
Argentate of ammonia, (fulminating ver)
Argenti nitras, ii. 273
Argentine flowers of antimony, ii. 174
Argentum vivum, ii. 242
Argillaceous iron stone, ii. 114; iii. 294
    lime stone, iii. 295
Argol, iii. 80
Arnold, of Villa Nova, i. 13
Arragonite, ii. 71, 376
Arrangement, chemical, i. ix. 191
Arrow-root, iii. 34
Arseniates, ii. 207, 532
    metallic, native, ii. 210
    of ammonia, ii. 207, 532
    — antimony, ii. 210
    — baryta, ii. 208, 532
    — bismuth, ii. 210, 533
    — cobalt, ii. 210, 533
    — copper, ii. 209, 533
    — —— analyzed, ii. 446
    — iron, ii. 209, 532
    — lead, ii. 210, 447, 533
    — lime, ii. 208, 447, 532
    — magnesia, ii. 208, 532
    — manganese, ii. 208, 532
    — mercury, ii. 259
    — nickel, ii. 236
    — potassa, ii. 207, 532
    — silver, ii. 279, 541
    — soda, ii. 208, 532
    — strontia, ii. 208, 532
    — tin, ii. 209, 532
    — uranium, ii. 210
    — zinc, ii. 209, 532
Arsenic, ii. 3, 202, 531
    acid, i. 168; ii. 203, 206, 531

- *Arsenic acid*, properties of,ii. 206
  - alloy of potassium with, ii. 215
  - alloys of, ii. 215
  - analysis of ores of, ii. 444
  - butter of, ii. 211
  - chloride of, ii. 210, 531
  - compound of, with hydrogen, ii. 211
  - compounds of, analyzed, ii. 444
  - effect of the blow-pipe on, ii. 341
  - hydriodate of, ii. 211
  - hydruret of, ii. 15, 212
  - iodide of, ii. 211
  - instruction for the detection of, ii. 216
  - native, ii. 203
  - obtained, ii. 202
  - oxides of, ii. 203, 531
  - phosphate of, ii. 215
  - phosphuret of, ii. 215
  - properties of, ii. 203
  - sulphate of, ii. 215
  - sulphurets of, ii. 213, 531
  - tests of, ii. 216, 341, 531
  - white, ii. 204
  - ——— treatment for poisoning by, ii. 204
  - ——— oxide of, ii. 203
- *Arsenical cobalt*, analysis of, ii. 425
  - pyrites, ii. 215, 445
- *Arsenicane*, ii. 210 (chloride of arsenic)
- *Arsenici oxydum sublimatum*, ii. 203
- *Arsenious* acid, i. 168 ; ii. 203, 531
  - sources of, ii. 204
  - properties of, ii. 204
  - tests of, ii. 216, 531
- *Arsenites*, alkaline, ii. 205
  - earthy, ii. 205
  - metallic, ii. 206
- *Arsenite of copper*, i. 168, 206
  - silver, ii. 279
- *Arseniuretted hydrogen*, ii, 211
  - decomposed by chlorine, ii. 213
- *Artephius*, i. 9
- *Arterial blood*, iii. 221
- *Artificial medicated waters*, i. 147
  - camphor, iii. 63
  - cold, how produced, i. 239 ; iii. 150
  - fat, iii. 211
  - gelly, iii. 179
  - gems, ii. 304
  - gum, iii. 34
  - tannin, iii. 46
  - wax, iii. 209
- *Asbestus*, ii. 102, 318
- *Ascent in a balloon*, the first, i. 5
- *Ashmole, Elias*, i. 23
- *Asparagin*, iii. 41
- *Asparagus stone*, ii. 70
- *Aspect of granite*, iii. 254, 258
  - mountain limestone, iii. 286
- *Asphaltum*, iii. 75
- *Assafœtida*, iii. 66
- *Assay pound*, ii. 291
  - furnace, i. xiii. xv.
  - of metalliferous compounds, ii. 332
  - — copper ores, ii. 411
  - — gold, ii. 291
  - — iron ores, ii. 383
  - — lead ores, ii. 415
  - — mercurial ores, ii. 459
  - — silver ores, ii. 281
  - — tin ores, ii. 401
  - — zinc ores, ii. 396
- *Atacamite*, ii. 152
- *Atmosphere*, i. 370
  - Priestley on the, i. 137
  - Lavoisier on the, i. 175
  - aqueous vapour in the, i. 384
  - carbonic acid in the, i. 384, 429
  - composition of the, i. 384
  - effect of, on crystallization, i. 196
  - mechanical properties of the, i. 371
  - nitrogen in the, i. 384
  - oxygen in the, i. 384
  - pressure of the, i. 370, 371, 373
- *Atmospheric air*, i. 369, 465
  - analysis of, i. 380
  - constituents of, i. 175

Atmospheric air, composition of, i. 384
  properties of, i. 370
  refraction of, i. 288
  weight of, i. 373
  electricity, i. 279
  pressure affects boiling points, i. 241
Atomic theory, i. 82, 219
Atropia, iii. 116
  its sulphate, iii. 116
Attraction of metals for oxygen, ii. 12
  opposed by heat, i. 223
Attraction, aggregative, i. 192
  elective, i. 216
  electrical, i. 249
  gravitative, i. 192
  heterogeneous, i. 213
  homogeneous, i. 192
  chemical, i. 213
  —— Bergman on, i. 79
  —— Berthollet on, i. 81
  —— Geoffroy on, i. 78
  —— Mayow on, i. 73
  —— Newton on, i. 75
Augite, ii. 319
Aura electrica, i. 260
Aurate of potassa, ii. 285
Aurora borealis, i. 282
Aurum musivum, ii. 144
Automalite, ii. 312
Aranturine, ii. 307
Axe stone, ii. 316
Axinite, ii. 317
Azote, i. 176, 346
  described by Mayow, i. 70
Azotane, i. 357
Azure, ii. 192

BACON, LORD, his character of the alchymists, i. 4
  Roger, i. 9
  —— his works, i. 10
Balass ruby, ii. 312
Balloon, i. 158, 330
  history of the, i. 158
  hydrogen made by Cavallo, i. 158
  first ascent in a, i. 158
Balsam of Peru, iii. 103
  of Tolu, iii. 103
  — sulphur (sulphur in oil)
Balsams, iii. 65, 103
Bancroft, on colours, iii. 47
Barege waters, ii. 502
Barilla, ii. 53
  the alcali in, ascertained, ii. 354
Barium, ii. 77, 512
Barium, obtained, ii. 77
  analysis of compounds of, ii. 374
  its amalgam, ii. 77
  — chloride, ii. 82, 512
  — iodide, ii. 82, 512
  — peroxide, ii. 78
  — phosphuret, ii. 87, 513
  — oxides, ii. 77, 512
  — properties, ii. 77
  — salts, table of, ii. 513
  — sulphuret, ii. 83, 513
  — tests, ii. 512
Bark of trees, iii. 2
  Peruvian, iii. 112
Barks, iii. 112
Barley, conversion of, into malt, iii. 31
  its composition, iii. 37
Barolite (carbonate of barytes) ii. 88
Barometer, i. 370
  mountain, i. 371
  exhibits electric phænomena, i. 268
  depression of, in a balloon, i. 159
Baroselenite, ii. 85
Bartholomew Schwartz, discovery of gunpowder attributed to, i. 12
Barya, ii. 77
Baryta, ii. 77, 512
  obtained, ii. 77
  distinguished from strontia, ii. 94
  water, ii. 78
  its acetate, iii. 165, 346

Baryta, appearance before the blow-pipe, ii. 339
— arseniate, ii. 208, 532
— arsenite, ii. 205
— base, ii. 77
— benzoate, iii. 105, 346
— bi-phosphate, ii. 87
— borate, ii. 88, 514
— camphorate, iii. 68
— carbonate, ii. 88, 513
— —— analyzed, ii. 374
— chlorate, ii. 82, 512
— chromate, ii. 223, 534
— citrate, iii. 95, 345
— composition, ii. 77, 375, 513
— hydrate, ii. 77, 512
— hydriodate, ii. 82, 513
— hydrosulphuret, ii. 83
— hypophosphite, ii. 87
— hyposulphate, ii. 84
— hyposulphite, ii. 83, 513
— iodate, ii. 82, 513
— muriate, ii. 82
— —— used as a test, i. 143
— nitrate, ii. 83, 513
— oxalate, iii. 89, 348
— phosphate, ii. 87, 513
— phosphite, ii. 87, 513
— properties, ii. 77
— salts, table of, ii. 512
— seleniate, ii. 441
— sesquiphosphate, ii. 87
— solution, ii. 78
— succinate, iii. 67, 346
— sulphate, ii. 85, 513
— —— analyzed, ii. 374
— sulphite, ii. 84, 513
— sulphovinate, iii. 154
— sulphuret, ii. 83, 513
— tartrate, iii. 82, 347
— tests, i. 142; ii. 88, 339, 512
— tungstate, ii. 228
— uses as a test, i. 143. ii. 88
Basalt, iii. 298, 300
Basalt, origin of, iii. 301
columnar, iii. 301
aspect of iii. 302
decomposition of, iii. 312
localities of, iii. 301
Basil Valentine, i. 28, 97
on antimony, ii. 3
nitric acid, i, 30
sulphuric acid, i. 33
Bases in dyeing, iii. 47
Basins, chalk, iii. 296
Bastard sugar, iii. 25
Bath-stone, iii. 295
waters, ii. 502
Batley, on senna, iii. 116
Battery, electrical, i. 267
voltaic, i. 187, 270
Baumé, on the Arbor Dianæ, ii. 274
Beccher, i. 64
his physica subterranea, i. 65
— idea of material elements, i. 65
Beer, manufacture of, iii. 128
fermentation of, iii. 129
Beet sugar, iii. 27
Beguin on calomel, ii. 245
Bell-metal, ii. 162
ore analyzed, ii. 399
Bennet on the electricity of metals, i. 186
Bennet's electrometer, i. 251
electrical doubler, i. 266
Ben-Neris, iii. 268
Benzoate of alumina, iii. 106
— ammonia, iii. 104, 349
— baryta, iii. 105, 350
— bismuth, iii. 106
— cobalt, iii. 106
— copper, iii. 106
— iron, iii. 105
— lead, iii. 104, 106, 350
— lime, iii. 105, 350
— magnesia, iii. 105
— manganese, iii. 105
— mercury, iii. 105
— nickel, iii. 106

Benzoate of potassa, iii. 105, 349
— silver, iii. 106
— soda, iii. 105, 350
— strontia, iii. 105
— uranium, iii. 106
— zinc, iii. 105
Benzoates, iii. 104, 349
Benzoic acid, i. 170 ; iii. 103, 349
analysis of, iii. 104
Benzoin, iii. 103
Berard on artificial fat, iii. 211
Bergman, i. 79, 138, 162
his opinion of transmutation, i. 17
— improvement of analytical chemistry, i. 140
on aërial acid, i. 152
— carbonic acid, i. 162
— carbonates of potash, ii. 43
— chemical analysis, i. 141
— —— affinity, i. 149
— crystallization, i. 197
— elective attraction, i. 79, 153
Berard on radiant heat, i. 293
Berthollet on chemical affinity, i. 81
— chlorine, i. 167
— eudiometry, i. 383
— fulminating silver, ii. 269
— gunpowder with chlorate of potassa, ii. 34
Beryl, ii. 328
Berzelius, on acetate of lead, iii. 168
— acetic acid, iii. 163
— amylate of lead, iii. 31
— benzoic acid, iii. 104
— on boracic acid, i. 454
— carburet of sulphur, i. 452
— cerium, ii. 4, 197
— citric acid, iii. 93
— colouring matter of the blood, iii. 181
— columbium, ii. 230
— cream, iii. 183
— gallic acid, iii. 100
— green tourmaline, ii. 471
Berzelius on gummate of lead, iii. 19
— lactic acid, iii. 185
— lithia, ii. 341
— lichen islandicus, iii. 125
— nitrate of ammonia, i. 369
— nitrites of lead, ii. 167
— oxalate of lead, iii. 88
— oxides of antimony, ii. 175
— —— chromium, ii. 223
— —— manganese, ii. 105
— —— platinum, ii. 292
— phosphate of baryta, ii. 87
— —— of lead, ii. 170
— —— silver, ii. 278
— rubilite, ii. 471
— saccharate of lead, iii. 28
— selenium, ii. 4, 201, 440
— serum, iii. 177
— starch, iii. 33
— sugar, iii. 28
— sugar of milk, iii. 184
— tannate of lead, iii. 45
— tartaric acid, iii. 79
— thorinum, ii. 4, 331, 482
— ulmin, iii. 38
— urine, iii. 197
— wavellite, ii. 312
— yttria, ii. 330
Bezoar mineral, ii. 174
Bi-carbonate of ammonia, i. 433, 469
— magnesia, ii. 101, 517
— potassa, ii. 45, 507
— soda, ii. 54, 509
Bi-carburetted hydrogen, i. 435, 469
Bi-chloride of copper, ii. 150, 524
of iron, ii. 116, 518
— mercury, ii. 247, 537
— phosphorus, i. 409, 468
— tin, ii. 142, 522
Bi-hydroguret of carbon, i. 435
of phosphorus, i. 412
Bile, iii. 186
action of, in the intestines, iii. 220
of oxen analyzed, iii. 186

Bile, resin of, iii. 186
peculiar matter in, iii. 186
composition of, iii. 187
calculi of, iii. 187
Biliary calculi, iii. 187
Binacetate of lead, iii. 168
of alumina, iii. 170
Binarseniate of potassa, ii. 207, 532
Binoxalate of potassa, iii. 89
Biot on refractive powers, i. 288
on air-bladders of fish, iii. 225
— polarization, i. 291
and Gay-Lussac, ascent of in a balloon, i. 160
Bi-persulphate of mercury, ii. 257
Bi-phosphate of baryta, ii. 87
of lime, ii. 69, 512
— magnesia, ii. 100, 516
— potassa, ii. 43, 507
— soda, ii. 53, 509
Bi-phosphuretted hydrogen, i. 410
Bird-lime, iii. 36
Biscuit of potters, ii. 321
Bismuth, ii. 3, 184, 528
procured, ii. 184
analysis of compounds of, ii. 421
and gold, ii. 290
its acetate, iii. 169, 350
— alloys, ii. 186
— arseniate, ii. 210, 533
— benzoate, iii. 106
— butter, ii. 185
— chloride, ii. 184, 528
— citrate, iii. 96, 349
— hydrosulphuretted oxide of, ii. 186
— iodate, ii. 185
— iodide, ii. 185, 528
— magistery, ii. 185
— nitrate, ii. 185, 528
— —— a sympathetic ink, ii. 186
— ores, ii. 421
— —— analyzed, ii. 421
— oxalate, iii. 92, 348
Bismuth, oxide of, ii. 184, 346, 528
— —— analyzed, ii. 423
— salts, ii. 528
— phosphate, ii. 186
— phosphuret, ii. 186
— properties, ii. 184
— sulphate, ii. 186, 528
— sulphuret, ii. 186, 421, 528
— tartrate, iii. 85, 347
— tests, ii. 346, 528
Bismuthic silver analyzed, ii. 460
Bismuthane (chloride of bismuth) ii. 184
Bi-sulphate of ammonia, i. 379
of manganese, ii. 108
potassa, ii. 40, 506
— soda, ii. 52, 508
Bi-sulphuret of arsenic, ii. 531
of copper, ii. 154, 524
— iron, ii. 118, 519
— mercury, ii. 255, 538
— tin, ii. 144, 522
Bitartrate of ammonia, iii. 79
of potassa, iii. 80
Bitter principle, iii. 39
—— artificial, ii. 40, 50
salt, ii. 98
spar, ii. 102
Bittern, ii. 98
Bitumen, elastic, iii. 76
Bitumens, iii. 75
Bituminous limestone, ii. 72
Black, Dr., his chemical researches, i. 99, 114
on causticity, i. 115
— change of state of bodies, i. 238
— carbonates of potash, ii. 43
— congelation, i. 120
— fixed air, i. 116
— heat, i. 117, 238
— hydrogen for balloons, i. 158
— liquefaction, i. 119, 239
— magnesia, i. 115
— on specific heat, i. 232
— vaporization, i. 121, 244

Black ash, iodine obtained from, i. 323
coal, iii. 76
dye for vegetable substances, iii. 48
ivory, iii. 216
jack, ii. 136
lamp, i. 418
lead, ii. 121
marble, iii. 288
ore of tellurium analyzed, ii. 438
oxide of iron, ii. 111
Blanc de fard, ii. 185
Bleaching, i. 319
by sulphurous acid gas, i. 389
liquor extemporaneous, ii. 34
powder, ii. 63
Blende, ii. 136
analyzed, ii. 391, 393
Blood, iii. 176
arterial, iii. 221, 224
venous, iii. 221, 224
effects of respiration on, iii. 223
its albumen, iii. 177
— aëration, iii. 223
— analysis, iii. 177
— appearance, iii. 176
— buffy coat, iii. 179
— circulation, iii. 221
— coagulation, iii. 176
— colouring matter, iii. 180
— composition, iii. 177
— crassamentum, iii. 176
— cruor, iii. 176
— fibrin, iii. 179
— red globules, iii. 180
— serosity, iii. 176
— serum, iii. 176
— —— analyzed, 176
— specific gravity, iii. 176
Blood-stone, ii. 307
Blow-pipe, ii. 334
oxyhydrogen, i. 330
Blow-pipe, directions for its use, ii. 335
its action on earths, ii. 339
— —— metallic oxides, ii. 341
Blow-pipe, its action on metallic aci
ii. 341
— —— urinary calculi, iii. 200
Blower in coal mines, what, i. 442
Blue colour from cobalt, ii. 191
dye, iii. 48
feldspar, iii. 253
John, ii. 73
lias limestone, iii. 295
prussian, ii. 122
—— Scheele on, i. 170
Saxon, iii. 48
vitriol, i. 47; ii. 156
Boerhaave, i. 112
Boiler, for experiments on steam, i. 24
Boiling and freezing simultaneously, ii
150
point, i. 241
—— varied by pressure, i. 241
Boletic acid, iii. 107, 126
Bologna phials, ii. 302
Bolognian phosphorus, i. 304; ii. 86
Bone earth, i. 405
Bones, iii. 212, 215
analysis of, iii. 215
distillation of, iii. 216
phosphorus from, i. 401, 405
Boracic acid, i. 54, 453, 470
native, i. 454
minerals containing it, ii. 471
obtained, i. 453
detected in mineral waters, ii. 500
reddens turmeric paper, i. 454
tinges flame green, iii. 145
its analysis, i. 454
— compounds analyzed, ii. 471
— decomposition, i. 453
— elements, i. 454
— properties, i. 454
— uses in analysis, ii. 470
Boracite, i. 254; ii. 101, 470
Borate of ammonia, i. 454, 470
baryta, ii. 88, 514
cobalt, ii. 192

Borate of copper, ii. 160, 525
iron, ii. 127
lead, ii. 171
lime, ii. 72, 512
magnesia, ii. 101, 517
mercury, ii. 259, 539
nickel, ii. 235, 537
potassa, ii. 46, 507
silver, ii. 279, 541
soda, ii. 56, 509
strontia, ii. 94, 515
tin, ii. 145
zinc, ii. 138, 521
Borates, metallic, ii. 22
Borax, i. 453 ; ii. 56, 363, 509
calcined, ii. 56
used in glass-making, ii. 299
—— as a flux, ii. 337
Boron, i. 453, 470
obtained, i. 453
Borurets, metallic, ii. 22
Bostock on albumen, iii. 178
gelatine, iii. 204
mucus, iii. 189
myrtle wax, iii. 53
saliva, iii. 189
Botryolite, ii. 471
Bottle glass, ii. 303
for specific gravity, ii. 7
Bouillon Lagrange on camphorates, iii. 68
Boulders, granite, iii. 270
Boulduc, i. 141
Boullay on picrotoxine, iii. 40
Bournonite, analysis of, ii. 418
Boyle, i. 55, 98
chemical tests used by, i. 140
on combustion, i. 61
— the graduation of the thermometer, i. 88
Boyle's fuming liquor, i. 400
Braamcamp on subpernitrate of mercury, ii. 253
Braconnot on acetate of mercury, iii. 170
Braconnot on dyeing with sulphuret of arsenic, ii. 214
— boletic acid, iii. 107
— the conversion of wood into gum and sugar, iii. 42
— fat and oil, iii. 200
— formation of ulmin, iii. 43
— ellagic acid, iii. 108
— fungin, iii. 41, 108, 126
— gallic acid, iii. 99
— gelatine, iii. 204
— leucine, iii. 207
— malic acid, iii. 97
— zumic acid, iii. 108
Bradley on light, i. 286
Brain, iii. 211
Branches of trees, iii. 2
Brandy, iii. 131, 135
Brass, ii. 3, 160
analysis of, ii. 161
its expansion by heat, i. 224
— composition, ii. 161
Brazil wood, iii. 114
infusion of, is a test, iii. 114
Breccia granitic, iii. 273
primitive, iii. 273
Brewing, process of, iii. 128
by steam, i. 246
Brewster on polarization, i. 291
Bricks, oil of, iii. 56
Brighton waters, ii. 502
Brilliants, i. 415
Brimstone, i. 386
Bristol diamonds, ii. 306
waters, ii. 502
British gum, iii. 34
Brittle metals, list of, ii. 9
Brodie on animal heat, iii. 226
on poisoning by arsenic, ii. 204
— oil of almonds, iii. 119
Bronze, ii. 162
Brooks on oxyhydrogen blow-pipe, i. 330
Brownrigg, Dr., chemical discoveries of, i. 116

Brown stout, iii. 135
Bruce on native magnesia, ii. 95
Brucine, iii. 73
Brunswick green, ii. 154 ; iii. 81
Bucholz on lycopodium, iii. 121
    on molybdenum, ii. 218
    — sulphuret of molybdenum, ii. 451
    — tungsten, ii. 225
    — uranium, ii. 193
Buffon's theory of the earth, iii. 238
Buffy blood, iii. 179
Bulbs, iii. 124
Burnet's theory of the earth, iii. 231
Butter, iii. 183
    is phosphorescent, i. 304
    of antimony, ii. 177
    — arsenic, ii. 211
    — bismuth, ii. 185
    — milk, iii. 183
    — tin, ii. 142
    — zinc, ii. 134
    milk, iii. 183
Buxton waters, ii 502

CADET on coffee, iii. 120
    — garlic, iii. 124
Cadmium, ii. 4, 146, 402, 523
    procured, ii. 146, 402
    analysis of compounds of, ii. 402
    its carbonate, ii. 404, 523
    — chloride, ii. 523
    — iodide, ii. 523
    — nitrate, ii. 403, 523
    — oxide, ii. 147, 346, 402, 523
    — phosphate, ii. 523
    — phosphuret, ii. 523
    — salts, ii. 523
    — sulphate, ii. 403, 523
    — sulphuret, ii. 523
    — tests, ii. 146, 346, 402, 523
Cairngorm, iii. 268
Calamine, ii. 137
    analyzed, ii. 394
Calcareous spar, i. 198 ; ii. 70
Calcined borax, ii. 56
    mercury, ii. 243
Calcis murias, ii. 62
Calcium, ii. 60, 510
    obtained, ii. 60
    analysis of its compounds, ii. 370
    its chloride, ii. 62, 510
    — fluoride, ii. 73, 75, 512
    — iodide, ii. 64, 511
    — oxide, ii. 60, 510
    — peroxide, ii. 62
    — phosphuret, ii. 68, 511
    — salts, table of, ii. 510
    — sulphuret, ii. 65, 511
Calculi biliary, iii. 187
    fusible, iii. 201
    mulberry, iii. 201
    urinary, i. 170 ; iii. 200
    —— varieties of, iii. 200
Calculus triple, iii. 200
Calico printing, iii. 52
Calomel, i. 170 ; ii. 244
    first described, i. 40
    its ancient names, ii. 245
    — composition, ii. 247
    — decomposition, ii. 250
    — preparation, ii. 245
    — properties, ii. 247
    — purity, test for, ii. 247
Caloric, i. 174, 248. *See Heat.*
    Lavoisier on, i. 174
Calorific rays, i. 293
Calorimeter, i. 234
Calx, i. 60
    hydrargyri alba, ii. 251
Calxes, theory of their formation, i. 66
Cameleon mineral, ii. 106
Camphor, iii. 61
    artificial, iii. 63
    acidification of, iii. 62
Camphorate of ammonia, iii. 63
    baryta, iii. 63
    lime, iii. 63

Camphorate of potassa, iii. 63
soda, iii. 63
Camphorates, iii. 63
Camphoric acid, iii. 62
Canton on the compressibility of water, i. 338
— phosphorescence, i. 305
Canton's phosphorus, i. 304
Caoutchouc, iii. 36
mineral, iii. 76
solution of, in ether, iii. 36
Capacity for heat, i. 232, 234
Caput mortuum vitrioli, ii. 120
Carbon, i. 414, 469
its pure forms, charcoal, i. 417
—— diamond, i. 414, 423
—— lamp black, i. 418
crystallized, i. 414
its chlorides, i. 433, 469
— combustion, i. 422
— hydro-chloride, i. 437, 469
— hydriodide, i. 438
— oxide, i. 420, 469
— phosphuret, i. 452
— sulphuret, i. 451, 470
— combination with chlorine, i. 433, 469
— —— hydrogen, i. 435, 469
— —— iron, ii. 121, 129
— —— metals, ii. 22
— —— nitrogen, i. 446, 469
— —— oxygen, i. 420, 469
— —— phosphorus, i. 452, 470
— —— sulphur, i. 451, 470
Carbonate of ammonia, i. 431, 469
—— procured, i. 431
baryta, ii. 88, 513
—— analyzed, ii. 374
cadmium, ii. 404, 523
cerium, ii. 198
cobalt, ii. 192, 529
copper, ii. 158, 525
iron, ii. 122, 520
lead, ii. 170, 527
—— analyzed, ii. 414
Carbonate of lime, i. 198, 429; ii. 70, 512
—— analyzed, ii. 370
—— native, ii. 70
—— phosphorescent, i. 304
lithia, ii. 59, 510
magnesia, ii. 100, 517
—— analyzed, ii. 378
manganese, ii. 109, 518
mercury, ii. 258, 539
morphia, iii. 70
nickel, ii. 235, 536
potassa, i. 221; ii. 43, 353, 358, 507
—— purity of, ii. 358
silver, ii. 279, 541
—— and ammonia, ii. 279
soda, ii. 53, 362, 509
—— in mineral waters, ii. 499
strontia, ii. 93, 376, 515
titanium, ii. 196
tin, ii. 145
zinc, ii. 137, 521
Carbonated mineral waters, ii. 502
Carbonates, i. 429
exist in mineral waters, ii. 490, 497
metallic, ii. 22
tests of the, ii. 490
Carbonic acid, i. 152, 177, 422, 469
procured, i. 426
solidifies solution of muriate of lime, ii. 63
in the atmosphere, i. 384, 429
in urine, iii. 192
of mineral waters, i. 427; ii. 489, 492
retards putrefaction, iii. 174
produced from the diamond, i. 177, 423
obtained by Dr. Brownrigg, i. 116
Bergman on, i. 152
Priestley on, i. 129
its absorption by charcoal, i. 419
— —— by water, i. 427
— analysis, i. 430
— composition, i. 422, 469
— decomposition, i. 430

Carbonic acid, its production by combustion, i. 422, 429
— —— fermentation, iii. 130
— —— respiration, i. 429; iii. 222, 225
— properties, i. 429
— refraction, i. 288
— solution of lime, iii. 311
— tests, i. 143, 429; ii. 70, 489
— weight, i. 154, 422
Carbonic oxide, i. 420, 469
procured, i. 420, 430
its absorption by charcoal, i. 419
— analysis, i. 421
— combustion, i. 420
— combination with chlorine, i. 301, 421
— composition, i. 421
— properties, i. 420
Carburet of nitrogen, i. 446
— phosphorus, i. 452
— sulphur, i. 451
Carburets, metallic, ii. 22
— of iron, i. 168; ii. 121, 129
Carburetted hydrogen, i. 435, 469
procured, i. 435
—— from oil, i. 441
—— — coal, i. 439
action of chlorine on, i. 437
economical application of, i. 439
light of, i. 441
its absorption by charcoal, i. 419
— analysis, i. 436
— combination with chlorine, i. 437
— combustion, i. 435
— composition, i. 436
— decomposition, i. 436
— properties, i. 435
— refraction, i. 288
Carglaise tin mine, iii. 271
Carlsbad waters, ii. 502
Carmine, iii. 51
Carminium, iii. 51
Carnelian, ii. 307
Carrot, composition of, iii. 37
Cascarilla, iii. 114
Cassava, iii. 35
Cassius, powder of, ii. 143, 287
Cast iron, grey, ii. 127
white, ii. 127
varieties of, ii. 127
Cast steel, ii. 129
Catechu, iii. 44
Caustic, lunar, ii. 274
potassa, ii. 31
Causticity, Black on, i. 115
Cavallo, made the first hydrogen ba
loon, i. 158
his electrical multiplier, i. 266
Cave of Fingal, iii. 303
Cavendish, i. 138, 156
on eudiometry, i. 383
— fixed air, i. 157
— hydrogen, i. 156, 326
— inflammable air, i. 157
— nitrous air, i. 157
— nitric acid, i. 33, 156, 352
Caventou, on brucine, iii. 73
— cinchona, iii. 112
— sulphate of morphia, iii. 70
— strychnine, iii. 72
Cavern in limestone, iii. 286
Cawk, ii. 85
Celestine, ii. 92
Cementation, ii. 129
Centipede, luminous, i. 305
Centigrade thermometer, i. 90, 229
Cerasin, iii. 20
Cerates, iii. 54
Cerebral substance, iii. 212
Cerin, iii. 54
Cerine, iii. 43, 54
Cerite, ii. 197
analyzed, ii. 432
Cerium, ii. 4, 197, 530
acetate of, iii. 169
analysis of its ores, ii. 432

Cerium, minerals containing, ii. 197, 432
muriate of, ii. 198
oxides of, ii. 198, 344, 530
prepared, ii. 197
preparations of, ii. 198
sulphate of, ii. 198
tartrate, iii. 86
test for, ii. 344
Ceruse, ii. 170
Cetic acid, iii. 211
Cetine, iii. 211
Ceylanite, ii. 312
Chabasite, ii. 313
Chalcedony, ii. 307
Chalk, ii. 72; iii. 295
its geological relations, iii. 295
situation, iii. 296
basins, iii. 296
beds described, iii. 296
its localities, iii. 296
organic remains in, iii. 296
Chalybeate waters, ii. 502
— tested, ii. 490
Chameleon mineral, ii. 106
Change of state, by chemical affinity, i. 214
produces electricity, i. 268
Characters of the seven ancient metals, ii. 3
Characters of primitive rocks, iii. 267
Charcoal, i. 417
obtained, i. 417
properties of, i. 418
is antiseptic, i. 418
absorbs gases, i. 419
its increase in weight in the air, i. 419
quantity produced by different kinds of wood, i. 418
prepared for gunpowder, iii. 162
animal, iii. 173
Charge, electrical, i. 260
Charles, his ascent in a balloon, i. 159
and Roberts, their ascent in a balloon, i. 158
Cheese, iii. 183
Cheese-wring Tor, iii. 272
Cheltenham waters, ii. 502
Chemical action, i. 213
—— its general effects, i. 214
—— the result of affinities, i. 214
—— requires apparent contact, i. 216
—— induced by electricity, i. 274
—— —— solar light, i. 301
—— —— voltaic light, i. 341
—— —— heat, i. 216
affinity, i. 213
—— Bergman on, i. 149
—— Davy on, i. 81
—— Geoffroy on, i. 78
—— Mayow on, i. 74
—— Newton on, i. 75
—— Pfaff on, i. 81
—— Richter on, i. 83
—— how exerted, i. 214
—— — modified, i. 216
—— definite, i. 214, 219
—— diagrams of, i. 218
—— estimate of its strength, i. 216
—— illustrations of, i. 213
—— modified by cohesion, i. 216
—— —— heat, i. 216
agency of the Voltaic pile, i. 187, 269
apparatus, i. xiii., 312; ii. 486
arrangement, i. ix., 191
attraction, i. 213
changes, general laws of, i. 191
—— influence of radiant matter in producing, i. 165, 300
—— occasioned by electricity, i. 186
composition indicated by crystalline characters, i. 213
decomposition, i. 216
equivalents, i. 222
—— table of, i. 464; ii. 505; iii. 345
elements of the alchymists, i. 42

Chemical laboratory, i. xiii.
medicines introduced, i. 37, 39
nomenclature, i. 173, 176, 183, 309
tables, Geoffroy's, i. 78, 217
Chemistry, defined, i. 191
its objects, i. 191
— history, i. 1
classification of its objects, i. 191
vegetable, iii. 1
pneumatic, improved by Priestley, i. 127
analytical, improved by Bergman, i. 141
—— —— — Klaproth, i. 148
Chenevix, on analysis of siliceous minerals, ii. 470
— arseniates of copper, ii. 209, 446
— —— iron, ii. 209
— calomel, ii. 246
— chlorate of soda, ii. 50
— murio-carbonate of lead, ii. 414
— phosphate of copper, ii. 158
— pyro-acetic spirit, iii. 164
Cherry-tree gum, iii. 20
Chevillot on mineral chameleon, ii. 106
Chevreul on artificial bitter principle, iii. 40
— camphor, iii. 62
— cerin, iii. 43
— cetic acid, iii. 211
— cholesterine, iii. 187
— fat and oil, iii. 209
— hematine, iii. 39
— indigo, iii. 49
— margaritic acid, iii. 210
— oleic acid, iii. 210
— oils, iii. 55
— subnitrate of lead, ii. 167
— subnitrites of lead, ii. 167
— sulphite of copper, ii. 156
Children, on cerium, ii. 197
on cadmium, ii. 147
— iridium, ii. 263
— meteoric iron, ii. 412
Children on a large voltaic battery, 277; ii. 198
— the use of the blow-pipe, ii. 335
Chimborazo, iii. 268
China, porcelain, ii. 321
Chlorate of ammonia, i. 365, 466
of baryta, ii. 82, 512
— bismuth, ii. 185
— copper, ii. 152
— lead, ii. 166, 526
— lime, ii. 63, 511
— lithia, ii. 510
— magnesia, ii. 97, 515
— manganese, ii. 107
— mercury, ii. 251, 537
— potassa, i. 311; ii. 33, 351, 505
— —— composition of, ii. 35, 505
— —— detonates with combustibles ii. 33
— —— action of sulphuric acid on i. 320; ii. 34
— silver, ii. 272, 540
— soda, ii. 50, 507
— strontia, ii. 90, 514
— zinc, ii. 135, 520
Chlorates, i. 322, ii. 14
Chloric acid, i. 322, 464
procured, i. 322
its properties, i. 322
— composition, i. 322, 341
— action on metals, ii. 14
ether, i. 437
oxide, i. 321, 464; ii. 34
Chlorides, ii. 13
native, ii. 4
nomenclature of, i. 309
of antimony, ii. 176, 527
— arsenic, ii. 210, 531
— barium, ii. 82, 512
— bismuth, ii. 184, 528
— cadmium, ii. 523
— calcium, ii. 62, 510
— —— absorbs ammonia, ii. 63
— carbon, i. 433, 469

Chloride of cobalt, ii. 188, 520
— copper, ii. 150, 524
— —— analyzed, ii. 404
— gold, ii. 284, 542
— iodine, i. 325, 464
— iron, ii. 115, 518
— —— analyzed, ii. 384
— lead, ii. 165, 526
— lithia, ii. 58, 510
— magnesium, ii. 96, 515
— manganese, ii. 106, 517
— mercury, ii. 244, 537
— nickel, ii. 233, 536
— nitrogen, i. 357, 465
— phosphorus, i. 409, 468
— —— decomposition of water by, i. 409
— platinum, ii. 293
— potassium, ii. 32, 505
— selenium, ii. 441
— silver, ii. 270, 540
— sodium, ii. 48, 361, 507
— strontium, ii. 90, 514
— sulphur, i. 397, 467
— tellurium, ii. 200, 530
— tin, ii. 141, 522
— —— analyzed, ii. 398
— uranium, ii. 193
— zinc, ii. 134, 520
— —— analyzed, ii. 390.
Chlorine, i. 166, 309, 318, 464
Berthollet on, i. 167
Davy on, i. 167, 318
Scheele, i. 167, 318
its action on carburetted hydrogen, i. 437
— —— ammonia, i. 365
— —— copper leaf, ii. 150
— —— gold, ii. 284
— nature, i. 320
— oxide, i. 320
— preparation, i. 318
— properties, i. 318
— solution, i. 319
Chlorine, its action supports combustion, i. 319
— weight, i. 319, 464
charcoal heated in, i. 319
combines with carbon, i. 433, 469
—— carbonic oxide, i. 301
—— carburetted hydrogen, i. 437
—— cyanogen, i. 448
—— hydrogen, i. 341, 465
— —— by solar light, i. 301, 341
—— iodine, i. 324, 464
—— metals, i. 319 ; ii. 13
—— nitrogen, i. 357, 465
—— oxygen, i. 320, 464
—— phosphorus, i. 319, 408, 468
—— sulphur, i. 396, 467
Chloriodic acid, i. 325, 341, 464
Chloriodine, i. 325, 464
Chlorocarbonic acid, i. 421, 469
Chlorocyanic acid, i. 448, 470
composition, i. 449
Chlorite, iii, 281
Chlorophane, ii. 74
Chlorophile (from leaves),
Chlorous acid, i. 322
oxide, i. 320
Choak-damp, i. 116, 429
Cholesterine, iii. 187
Choulant on carbonate of morphia, iii. 70
— meconiate of ammonia, iii. 71
Chromate of ammonia, ii. 223, 534
baryta, ii. 534
iron, ii. 222, 534
—— analyzed, ii. 452
lead, ii. 222, 535
—— analyzed, ii. 451
lime, ii. 534
mercury, ii. 222, 259
potassa, ii. 223, 534
—— used as a test, ii. 224
silver, ii. 279, 542
soda, ii. 223
Chromic acid ii. 221 ,534

Chromic acid, its properties, ii. 222
Chromium, ii. 4, 221, 534
its oxides, ii. 221, 534
— ores analyzed, ii. 451
— properties, ii. 221
— salts, ii. 534
— tests, ii. 342, 534
— appearance before the blowpipe, ii. 342
Chrysocolla, ii. 159
Chrysolite, ii. 102, 312, 381
of Vesuvius, ii. 315
Chrysoprase, ii. 307
Chyazic acid, ferruretted, ii. 125
sulphuretted,
Chyle, iii. 219
its properties, iii. 219
— coagulation, iii. 219
Chyme, iii. 217
Cider, iii. 135
Cinchona, iii. 112
Cinchonine, iii. 112
its gallate, iii. 113
— muriate, iii. 113
— nitrate, iii. 113
— sulphate, iii. 113
Cinnabar, ii. 242, 255
how prepared, ii. 255
its nature, ii. 255
native, ii. 256
—— analysis of, ii. 459
Cinnamon stone, ii. 314
Circulation of the blood, iii. 222
Citrate of ammonia, iii. 94, 349
baryta, iii. 95, 349
bismuth, iii. 96, 349
cobalt, iii. 96, 349
copper, iii. 96, 349
iron, iii. 349
lead, iii. 96, 349
lime, iii. 94, 349
magnesia, iii. 95, 349
manganese, iii. 95, 349
mercury, iii. 96, 349
Citrate of nickel, iii. 96, 349
potassa, iii. 94, 349
silver, iii. 96, 349
soda, iii. 94, 349
strontia, iii. 95, 349
tin, iii. 95, 349
uranium, iii. 96
zinc, iii. 95, 349
Citric acid, i. 170; iii. 93, 348
procured, i. 170; iii. 93
properties of, iii. 93
its combinations, iii. 94
— composition, iii. 94
Classes of the metals, ii. 27
Classification of metals, ii. 25
Clay, ii. 320
marly, ii. 320
pipe, ii. 320
porcelain, ii. 320
potters', ii. 320
Claying of Sugar, iii. 25
Clay iron-stone, ii. 114; iii. 294
slates, iii. 280
Cleavage of crystals, i. 197
Clement on carbonic oxide, i. 420
Clunch, iii. 292
Clyssus of nitre, ii. 38
Coagulable lymph, iii. 179
Coagulation of the blood, iii. 176, 179
Coagulum of the blood, iii. 176
chyle, iii. 219
Coak, iii. 77
Coal, iii. 76; iii. 291
black, iii. 76
varieties of, iii. 76, 292
mines, iii. 292
geological situation of, iii. 291
glance, iii. 77
origin of, iii. 293
pit, iii. 76
products of, i. 440
basin, iii. 293
best kinds of for gas-making, i. 446
gas, i. 439, 442

oal gas, obtained by Dr. Hales, i. 101
— apparatus, i. xiv. 439
— purification of, i. 439
— analysis of, i. 445
mines, fire-damp of, i. 442: iii. 292
oating for retorts, i. 408
obalt, ii. 3, 187, 529
analysis of its compounds, ii. 424
and nickel separated, ii. 425
impure, analyzed, ii. 424
its acetate, iii. 169
— alloys, ii. 192
— ammoniuret, ii. 190
— arseniate, ii. 187, 210, 533
— benzoate, iii. 106
— borate, ii. 192
— carbonate, ii. 192, 529
— chloride, ii. 188, 529
— citrate, iii. 96, 349
— ferrocyanate, ii. 192
— hydrate, ii. 188
— hydrosulphuretted oxide, ii. 191
— iodide, ii. 190
— muriate, ii. 189, 529
— nitrate, ii. 190
— ores, ii. 187
— —— analyzed, ii. 424
— oxalate, iii. 92, 348
— oxides, ii. 188, 347, 529
— peroxide, ii. 188, 529
— phosphate, ii. 191, 529
— phosphuret, ii. 191, 529
— preparation, ii. 187
— properties, ii. 188
— protoxide, ii. 188, 529
— sulphate, ii. 190, 529
— —— anhydrous, ii. 190
— sulphuret, ii. 190, 529
— tartrate, iii. 347
— tests, ii. 192, 347, 529
and gold, ii. 290
blue, ii. 191
Coccinellin, iii. 51
Cochineal, iii. 51
Coccolite, ii. 319
Cocculus Indicus, iii. 40
Coffee, iii. 120
Cohesion, i. 192
its influence over chemical attraction, i. 216
Coke, iii. 77
Colcothar, i. 32, 35; ii. 120
Cold, supposed nature of, i. 94
sensation of, i. 238
radiation of, i. 93
reflection of, i. 98
produced by liquefaction, i. 239
—— evaporation, i. 122, 247; iii. 149, 150
expansion of water by, i. 228
artificial, i. 120, 122, 247; iii. 149
—— produced, i. 239; iii. 149, 150
Cold-short iron
Coloured flame, iii. 145
Coloured glass, ii. 304
Colouring matter, iii. 47, 114
of blood, iii. 180
— flowers, iii. 117
— fruits, iii. 122
— woods, iii. 115
Colours, theory of, i. 292
affect the receptive powers of bodies for solar heat, i. 298
do not affect the receptive power of bodies for terrestrial heat, i. 299
vegetable, destroyed by chlorine, i. 319
—— charcoal, i. 418
—— sulphurous acid, i. 388
changed by chemical action, i. 215
adjective, iii. 47
substantive, iii. 47
in dyeing, iii. 47
of steel, ii. 133
Columbate of potassa, ii. 281, 585
Columbic acid, ii. 280, 585
Columbite, ii. 280, 454

Columbium, ii. 4, 229, 535
acid of, ii. 230, 535
ores of, ii. 229
— analyzed, ii. 454
properties of, ii. 230
oxide of, ii. 230, 343, 535
preparations of, ii. 230
tests of, ii. 231, 343
Column, electrical, i. 270
Combined heat, i. 239
Combustible bodies, simple, i. 326
Combustion, history of the theory of, i. 50
alchymical notion of, i. 60
Hooke's theory of, i. 59, 130
Phlogistic hypothesis of, i. 64
Stahl's hypotheses of, i. 66, 316
Lavoisier on, i. 176, 317
nature of, i. 317
increases the weight of bodies, i. 60, 66
supported by oxygen, i. 316
consumes oxygen, i. 316, 317
simple supporters of, i. 309
without flame, i. 306
of the metals, ii. 12
— alcohol, iii. 144
— iron in oxygen, ii. 111
— —— chlorine, ii. 116
— the diamond, i. 423
air spoiled by, purified, i. 132
Common salt, ii. 48; iii. 290
mines of, iii. 289
Compact fluor, ii. 74
Complex decomposition, i. 217
Composition, indicated by crystalline characters, i. 213
of vegetable substances, iii. 10
— soils, iii. 327
Compound, chemical, i. 214
Compression of water, i. 338
Condensation changes the capacity of bodies for heat, i. 234
of water and alcohol by mixture, iii. 136
Condenser, electrical, i. 268, 265
Condensing electrometer, i. 266
Conducting power, electrical, i. 264,
of liquids for heat, i. 237
Conduction of heat, i. 235
Conductors of electricity, i. 263, 277
of heat, i. 235
— lightning, i. 280
Congelation, i. 241
Dr. Black on, i. 120
artificial, i. 239, 247; iii, 150
produces electricity, i. 268
Conglomerate, *granitic*, iii. 273
Constituents of vegetable bodies, table iii. 17, 127
Construction of thermometers, i. 229
Cooling vessels, i. 122
processes, i. 122
power of different substances, i.
Cooper, on alloys of platinum, ii. 295
oxide of platinum, ii. 292
Copal, iii. 65
Copper, ii. 148, 523
assay of its ores, ii. 411
ammoniated, ii. 153
native, ii. 149
action of chlorine on, ii. 150
white, ii. 242
azure, ii. 160
analysis of compounds of, ii. 40
and gold, ii. 290
its acetate, iii. 162, 166, 250
— alloys, ii. 160
— ammonio-nitrate, ii. 153
— —— sulphate, ii. 157
— ammoniuret, ii. 153
— arseniate, ii. 209, 210, 446, 5
— arsenite, i. 163; ii. 206
— benzoate, iii. 106
— bi-sulphuret, ii. 154, 524
— black sulphuret, ii. 154
— borate, ii. 160, 525
— carbonate, ii. 158, 526
— —— analyzed, ii. 410

Copper, its chlorate, ii. 152
its chlorides, ii. 150, 404, 524
— citrate, iii. 96, 349
— expansion by heat, i. 224
— ferrocyanate, ii. 160
— ferroprussiate, ii. 160
— hydrated oxide, ii. 149
— —— peroxide, ii. 153
— hyposulphite, ii. 156, 524
— iodide, ii. 152, 524
— muriate, ii. 150, 524
— nitrate, ii. 153, 524
— native sulphuret analyzed, ii. 405
— ores, ii. 148
— —— reduced, ii. 155
— oxalate, iii. 90, 348
— —— with ammonia, iii. 90, 348
— —— potassa, iii. 91, 348
— —— soda, iii. 91, 348
— oxides, ii. 149, 318, 404, 523
— perchloride, ii. 151, 524
— permuriate, ii. 151, 524
— peroxalate, iii. 90
— persulphate, ii. 156, 525
— persulphite, ii. 525
— phosphate, ii. 158, 525
— —— analyzed, ii. 409
— phosphuret, ii. 158, 525
— preparation, ii. 148
— protomuriate, ii. 151
— protochloride, ii. 150, 524
— properties, ii. 148
— pyrites, ii. 155
— rosin, ii. 150
— salts, ii. 523
— subacetate, iii. 167
— subcarbonate, ii. 158
— submuriate, native, ii. 152
— subpermuriate, ii. 151, 524
— subpernitrate, ii. 153
— subsulphate, ii. 157
— succinate, iii. 68, 346
— sulphate, i. 47; ii. 156, 525
— —— with potassa, ii. 158
Copper, its sulphite, ii. 156, 526
— —— with potassa, ii. 156, 526
— sulphuret, i. 213; ii. 154, 524
— tartrate, iii. 83, 347
— —— with potassa, iii. 83
— tests, i. 142, 143, 151; ii. 162, 348, 523
Copperas, ii. 119
Coral, iii. 215, 314
Cork, iii. 43
its acid, iii. 43
fossil, ii. 318
mountain, ii. 318
Cornish diamonds, ii. 306
Corrosive sublimate, ii. 247
prepared, ii, 248
its properties, ii. 249
— composition, ii. 249
— decomposition, ii. 250
— use as a test, i. 145
Cortical layers of plants, iii. 8.
Corundum, ii. 311
perfect, ii. 312
imperfect, ii. 312
Cotton, iii. 43
Cotyledon of seeds, iii. 4
Coulomb's electrometer, i. 253
Couronne des tasses, i. 271
Courtois, discovery of iodine by, i. 324
Crassamentum, iii. 176
Cream, iii. 183
of tartar, iii. 80
Crocus metallorum, ii. 178
Crellius, first described calomel, i. 40; ii. 244
Cronstedt on nickel, ii. 3
Cross stone, ii. 319, 375
courses, iii. 305
Crowe, Dr., on the anomalous expansion of water, i. 93
Crown glass, ii, 308
Crucibles, ii. 232, 233
platinum, i. xvi.
Crude tartar, iii. 80

Cruickshanks on carbonic oxide, i. 420
    gunpowder, ii. 89
    urine, iii. 194
Cruor, iii. 176
Crusts of lobsters, iii. 214
Cryolite, ii. 313
Cryophorus, Wollaston's, i. 122, 247
Crystal, rock, ii. 306 ; iii. 251
Crystallization, i. 193
    Wollaston on, i. 208
    Daniell on, i. 209
    theory of, i. 197, 208
    spherical theory of, i. 208
    requisites for, i. 198
    laws of, i. 193
    influenced by the air, i. 196
    —— light, i. 196
    hastened, i. 196
    retarded, i. 196
    water of, i. 194, 339
    separation of salts by, i. 195
    its indication of composition, i. 213
    of water, i. 338
Crystals, i. 193
    dissected, i. 210
    means of preserving them, i. 195
    their cleavage, i. 197
    — increments, i. 207
    — integral elements, i. 207
    — primitive forms, i. 205
    — regularity, i. 193
    — structure, i. 197
Cubic nitre, ii. 50
Cudbear, iii. 125
Cumming on the oxy-hydrogen blowpipe, i. 330
Cupel, ii. 282
Cupellation, ii. 164, 167, 281
Cupelling furnace, i. xv.
Cuprane (proto-chloride of copper), ii. 150
Cupranea (bi-chloride of copper), ii. 151
Cuprate of ammonia, ii. 154
Cupreous sulphuret of tin, analyzed, ii. 399
Cuprum ammoniatum, ii. 157
Curd, iii. 183
Current, electrical, i. 283
Curried leather, iii. 206
Curved strata, iii. 284
Cuticle, iii. 203
    of plants, iii. 2
Cutis, iii. 203
Cutting of diamonds, i. 415
Cuvier on organic remains, iii. 297
Cyanic acid, i. 447
Cyanides (cyanurets),
Cyanite, ii. 317
Cyanogen, i. 446, 469
    obtained, i. 446
    its properties, i. 447
    analyzed, i. 447
    decomposed, i. 447
    its composition, i. 448
    with chlorine, i. 448
    — hydrogen, i. 449
    — iodine, i. 449
Cyanuret of mercury, i. 446 ; ii. 268
    phosphorus, i. 451
    potassium, ii. 46
    silver, ii. 279
    sulphur, i. 451
Cylinder electrical machine, i. 255
Cystic oxide, iii. 202

DALTON on definite proportions, i. 8
    219
    the mixture of gases, i. 329
    eudiometers, i. 383, 385
    hydrated barytes, ii. 77
    sulphuric acid, i. 390
Damascus sabres, ii. 309
Damask, ii. 309
Damp, choak, i. 116, 429
    fire of coal mines, i. 442 ; iii. 298
Daniell on the theory of crystallization,
    209
    analysis of vegetable substance
    iii. 13

Daniell on cast iron, ii. 127, 306
lampic acid, iii. 154
sugar, iii. 28
vegetable substances, iii. 16
wrought iron, ii. 128
his hygrometer, i. 385
— analysis of compounds of iron, ii. 387
Dates of formations, iii. 279
veins, iii. 305
Datholite, analysis of, ii. 319, 471
Davy Sir H., on acids of phosphorus, i. 406
analysis of soils, iii. 316
—— by boracic acid, ii. 470
barium, ii. 77
boracic acid, i. 454
chemical affinity, i. 81
chlorine, i. 167, 318
chloriodic acid, i 325
deoxidizing rays, i. 302
electro-chemical phænomena, i. 275
eudiometry, i. 383
flame, i. 443
fluorine, ii. 73
glucinum, ii. 329
heat, i. 297
iodine, i. 324
iodo-cyanogen, i. 449
miner's safety lamp, i. 307, 443
muriatic acid, i. 51, 344
nitrate of ammonia, i. 369
nitro-muriatic acid, i. 357
nitrous oxide, i. 347
nomenclature, i. 184
nutritive principles of grain and pulse, iii. 87, 119
—— vegetables, iii. 127
oxymuriatic acid, i. 167
phosphorous acid, i. 404
potassium, ii. 4, 28
radiant matter, i. 95, 301
safety lamps, i. 444; iii. 294
sodium, ii. 4, 47
Davy Sir H., on sulphuretted cyanogen, i. 451
tannin, iii. 44
vegetation, iii. 6
volcanoes, iii. 315
voltaic electricity, i. 275
zirconia, ii. 328
Davy, Dr. J., on the analysis of chlorides of copper, ii. 404
—— —— tin, ii. 398
chlorides of arsenic, ii. 211
—— bismuth, ii. 185
—— lead, ii. 165
—— manganese, ii. 107
—— tellurium, ii. 200
—— silver, ii. 271
—— zinc, ii. 134
compounds of tin, ii. 141
fluoborates, ii. 76
number for antimony, ii. 175
phosgene gas, i. 421
submuriate of copper, ii. 152
uric acid in excrement of birds, iii. 199
Davy, E., on platinum and its compounds, ii. 293
test for gelatine, iii. 204
Deads, iii. 305
Death occasioned by electricity, i. 268
Decay of rocks, iii. 309
Decomposition, chemical, i. 216
compound, i. 217
double, i. 218
electrical, i. 273
simple, i. 217
single, i. 217
voltaic, i. 187, 273
—— laws of, i. 273
tables of, i. 218
of alcohol, iii. 146
— granite, iii. 269, 271
— rocks, iii. 269, 309
— organic substances, iii. 11
— vegetable substances, iii. 11

Decomposition of water, i. 273, 335
Decomposing rays of light, i. 301
    radiant matter, i. 301
Decrements of crystals, i. 207
Decrepitation, ii. 49
Definite proportions, theory of, i. 82, 186, 219, 222; ii. 13
    Dalton on, i. 84
    Gay-Lussac on, i. 85
    Higgins on, i. 84
    Richter on, i. 83
    Wollaston on, i. 84
De la Rive, on conversion of starch into sugar, iii. 33
De Lassone on ammoniuret of zinc, ii. 136
Delhuyart on tungsten, ii. 4
    wolfram, ii. 454
Deliquescence, i. 195
De Lisle's thermometer, i. 230
Delphine, iii. 74
De Luc's electric column, i. 270
    hygrometer, i. 385
Density affects refractive power, i. 287
    of oil of vitriol, i. 392
Deoxidizing rays, i. 302
Dephlogisticated air (oxygen), i. 309
    described by Priestley, i. 129
    marine acid, i. 318
    muriatic acid, i. 167, 318
Depolarization of light, i. 291
Derbyshire spar, ii. 73
Desaignes on the light of compressed water, i. 338
Descartes on radiation, i. 285
Descotils on fulminating silver, iii. 158
Desormes on carbonic oxide, i. 420
Destructive distillation of vegetables, iii. 11
    animal substances, iii. 172
Detection of arsenic, ii. 216
Detonating powders, ii. 84, 88
    tube, i. 333
Detonation of oxygen and hydrogen, i, 327, 333
Detonation of oxygen with chlorate potassa, ii. 33
Deutochloride of copper, ii. 151, 524
    iron, ii. 116, 518
    mercury, ii. 248, 537
    tin, ii. 141, 522
Deutofluate of cerium, ii. 482
Deutoxide of antimony, ii. 174, 527
    arsenic, ii. 206, 531
    cerium, ii. 198, 530
    chromium, ii. 221, 534
    cobalt, ii. 188, 529
    copper, ii. 149, 524
    barium, ii. 78
    iron, ii. 112, 518
    lead, ii. 164, 526
    manganese, ii. 105, 517
    mercury, ii. 243, 537
    molybdenum, ii. 219, 533
    nitrogen, i. 349
    potassa, ii. 31, 505
    soda, ii. 47, 507
    tin, ii. 140, 522
    uranium, ii. 531
Deutosulphate of manganese, ii. 106
Diabetes, iii. 197
Diabetic sugar, iii. 197
Diabolus metallorum, ii. 268
Diagrams of affinity, i. 218
Diallage, iii. 264
Diamond, i. 254, 414
    the purest form of carbon, i. 414
    a good conductor of heat, i. 235
    cutting of, 415
    its characters, i. 415
    — combustion, i. 423
    — localities, i. 414
    — nature, i. 177, 414, 423
    — refractive power, i. 288
    — valuation, i. 415
    — varieties, i. 415
    Bristol, ii. 306
    Cornish, ii. 306
    account of large ones, i. 416

Diaphoretic antimony, ii. 174
Diesbach, discovered prussian blue, i. 170 ; ii. 123
Differential thermometer, i. 231
Digestion, iii. 217
Digestive salt of Sylvius, ii. 33
Digby, Sir Kenelm, i. 22
Dilatation by heat, i. 223
  of fluids, i. 225
  — gases, i. 225
  — metals, i. 224
  on solidifying, i. 228
Dioptase, ii. 160
Dippel's animal oil, iii. 173
Distillation, i. 337
Distilled vinegar, iii. 161
  water, i. 337 ; iii. 60
Discharges, electrical, i. 260
Dissection of crystals, i. 210
Dolomite, ii. 102 ; iii. 266
Donovan on malic or sorbic acid, iii. 97
Dorking lime, ii. 325
Douault-Wieland, on artificial gems, ii. 304
Double decomposition, i. 217
  fluate of cerium and yttria, ii. 482
  refraction of light, i. 289
Doubler, electrical, i. 266
Draco mitigatus, ii. 245
Dragon's blood, (a red resin)
Drebble is supposed to have invented the thermometer, i. 86
Drying oils, iii. 56
Dubois on zirconia, ii. 327, 478
Du Clos, the analyst, i. 141
Ductility, ii. 8
Ductile metals, ii. 8
Duhamel on muriate of soda, ii. 50
Dulong on chloride of nitrogen, i. 358
  — hypophosphatic acid, i. 407
  — hypophosphite of potassa, ii. 42
  — hypophosphorous acid, i. 404
  — radiant heat, i. 299
  — specific heat, i. 233
Dutch gold (copper leaf)
Dyeing, ii. 214 ; iii. 47
Dykes, iii. 293, 298

EARTH, arrangement of its crust, iii. 242
  theory of, by Buffon, iii. 238
  — Burnet, iii. 231
  — Hutton, iii. 243, 255
  — Leibnitz, iii. 236
  — Werner, iii. 242, 257
  — Whiston, iii. 237
  — Whitehurst, iii. 237
  — Woodward, iii. 235
Earths, ii. 60, 297
  their nature guessed by Lavoisier, i. 178
  are metallic oxides, i. 178
  action of blow-pipe on, ii. 339
  tests for them, i. 143
  alcaline, ii. 13, 78
  —— baryta, ii. 77
  —— lime, ii. 60
  —— magnesia, ii. 95
  —— strontia, ii. 89
Ebullition, i. 241
  at diminished pressure, i. 241
  paradoxical, i. 242
Edwards, on mineral chamelion, ii. 106
Efflorescence, i. 195
Eel, electrical, i. 282
Egg, white of (albumen), iii. 176
Eggshell, iii. 214
Einhoff, on lentiles, iii. 119
  on potatoes, iii. 124
Ekeberg on columbium, ii. 229
  on tantalite, ii. 229
  — yttria, ii. 330
Elaine, iii. 55, 209
  obtained, iii. 55, 210
  its quantity in fats and oils, iii. 209
Elaolite, ii. 316
Elastic bitumen, iii. 76
  —— gum (caoutchouc) iii. 86

Elasticity of gases, i. 370
of metals, ii. 10
Elaterium, iii. 123
Elatin, iii. 123
Elective affinity, i. 216
Bergman on, i. 79
Electric calamine, ii. 138
— analyzed, ii. 395
fluid, i. 283
heat, i. 258
light, i. 249, 258, 284
spark, i. 258, 284
Electrical air-pistol, i. 327
amalgam, i. 256
attraction, i. 249
—— varies inversely as squares of distance, i. 253
aura, i. 260
battery, i. 267
charge, i. 260
column, i. 270
condensers, i. 263, 265
conductors, i. 253
—— polar arrangement of, i. 259
current, i. 283
discharger, i. 260
doubler, i. 266
eel, i. 282
induction, i. 255, 258
insulators, i. 253
jar, i. 259
—— theory of, i. 261
machine, i. 255
multiplier, i. 266
phænomena, natural, i. 279
phial, i. 259
points, i. 260
ray, i. 282
repulsion, i. 249
shock, i. 260, 268, 273
states, i. 250
Electricity, i. 250
its history, i. 186
Electricity, its modes of excitation, i. 186, 249, 254, 268
— cause, i. 283
— sources, i. 249, 254, 268
— theory, i. 283
— quantity, i. 266, 276
— intensity, i. 266, 276
— tension, i. 265
— chemical agencies, i. 186, 187, 27
animal, i. 282
atmospherical, i. 279
induced, i. 258
negative, i. 250, 261
positive, 250, 261
resinous, i. 250
vitreous, i. 250
voltaic, i. 268
—— theory of, i. 279
—— apparatus for, i. 269
—— improvements in, i. 270
conductors of, i. 253; ii. 5
insulators of, i. 253
metals, conductors of, ii. 5
non-conductors of, i. 253
produced by contact of metals, i. 18 268
—— friction, i. 249, 255
—— change of state, i. 268
produces magnetism, i. 273
metals burnt by, i. 268, 273; ii. 1
chemical decomposition by, i. 273
water decomposed by, i. 273, 335
transmission of elements by, i. 27
Electrics, i. 251
by heat, i. 254
Electro-chemical action, i. 273
Electrometer, i. 251
Bennet's, i. 251
condensing, i. 266
Coulomb's, i. 252
Henley's, i. 260
quadrant, i. 260
Singer's, i. 252
method of using the, i. 252

Electrometers, i. 186
Electrophorus, i. 263
Electroscopes, i. 251
Elements, and their compounds, tabular view of, i. 464
  of the alchemists, i. 43
  Beccher's, i. 65
  Stahl's, i. 66
  acidifiable and inflammable, i. 326, 464
  inherently negatively electrical, i. 309
  —— positively electrical, i. 326
  transmission of by electricity, i. 274
  integral of crystals, i. 207
Elias Ashmole, i. 23
Elias, the Artist, history of, i. 19
Eliquation, ii. 268
Ellagic acid, iii. 108
Emerald, ii. 328
  analyzed, ii. 479
  copper, ii. 160
Emery, ii. 312
Emetic tartar, preparation of, iii. 84
  properties of, iii. 85
  composition of, iii. 85
Emetine, iii. 41
Empyreal air of Scheele, i. 163
Emulsions, iii. 55
Enamel of teeth, iii. 215
  white, ii. 305
Enamels, ii. 140
Engine, steam, i. 123
England, strata of, iii. 250
Englefield, Sir H., on radiant heat, i. 293
  the mountain barometer, i. 371
English weights and measures, i. 457
Engraving on glass, ii. 75
Ens veneris, ii. 117
Epidermis, iii. 3
Epidote, ii. 317
Epsom salt, ii. 98
Equivalents, chemical, i. 222, 340
  tables of, i. 464; ii. 505; iii. 345
Erckern Lazarus, i. 148
Essential oils, iii. 58
Etching on glass, ii. 75
Ether, (sulphuric,) i. 170; iii. 147
  prepared, iii. 147, 148
  purification of, iii. 148
  properties of, iii. 149
  analysis of, iii. 151
  combustion of, iii. 151
  composition of, iii. 152
  volatility of, iii. 149
  latent heat in the vapour of, i. 245
  freezing of water by, iii. 150
  ignition without flame in the vapour of, i. 306; iii. 154
  inflammability of, iii. 151
  vapour of, iii. 149
  solution of gold in, ii. 287; iii. 150
  —— —— gilding by, iii. 151
  —— phosphorus in, iii. 150
  —— platinum in, iii. 150
  —— metals coated by, iii. 151
  action of chlorine on, iii. 153
  acetic, (Addenda, iii.)
  chloric, i. 437
  hydriodic, iii. 160
  muriatic, iii. 159
  nitric, iii. 155
  —— preparation of, iii. 156
  —— properties of, iii. 156
  —— composition of, iii. 157
  sulphuric, iii. 147
  —— procured, iii. 148
  —— properties of, iii. 149
  —— analysis of, iii. 152
Ethereal solution of gold, ii. 287; iii. 150
  platinum, iii. 150
Ethiops, martial, ii. 112
  mineral, ii. 254
  per se, ii. 243
Euchlorine, i. 320; ii. 34
  its preparation, i. 320
  — properties, i. 321
  — analysis, i. 321

Euchlorine, its composition, i. 341
— solution, i. 321
Euclase, ii. 329
Eudiometer, Berthollet's, i. 383
Cavendish's, i. 383
Dalton's, i. 383
Davy's, i. 383
Henry's, i. 382
Hope's, i. 382
Lavoisier's, i. 383
Pepys', i. 382
Priestley's, i. 131, 383
Scheele's, i. 381
Seguin's, i. 383
Volta's, i. 381
with hydrogen, i. 380
— nitrous gas, i. 382
— sulphurets, i. 163, 381
Eudiometry, i. 380
Priestley on, i. 131, 137
Scheele on, i. 163
Evaporating vessels, i. xv.
Evaporation, i. 247
for the production of crystals, i. 193
cold produced by, i. 122, 247; iii. 150
Examination of mineral waters by tests, ii. 487
Excitation of electricity, i. 249
Excrements of animals, iii. 219
Expansion, anomalous, of water, i. 91, 228, 462
of water by cold, i. 228, 462
alters the capacities of bodies for heat, i. 234
on solidification, i. 228
by heat, i. 223
—— of air, i. 226
—— — alcohol, i. 225
—— — brass, i. 224
—— — copper, i. 224
—— — fluids, i. 225
—— — gases, i. 225
—— — iron, i. 224
— —— lead, i. 224
Expansion, by heat, of mercury, i. 225
—— — metals, i. 224
—— — nitric acid, i. 225
—— — oil, i. 225
—— — oil of turpentine, i. 225
—— — platinum, i. 224
—— — solids, i. 224
—— — steel, i. 224
—— — sulphuric acid, i. 225
—— — tin, i. 224
—— — water, i. 225, 462
—— — zinc, i. 224
Extinction of flame by cooling, i. 307
wire gauze, i. 307
Extract, vegetable, iii. 38
Extractive matter, iii. 38
varieties of, iii. 38
Eye, humours of, iii. 189

FAHRENHEIT'S thermometer, i. 99, 229
Fall of Fyers, iii. 273
stones, ii. 237
Faraday on absorption of ammonia by chlorides, ii. 63, 271
— analysis of wootz, ii. 387
— chlorides of carbon, i. 433
— chloride of silver, ii. 270, 271
— hydriodide of carbon, i. 438
— hydrochloride of carbon, i. 437
— oxide of silver, ii. 269
— separation of iron and manganese, ii. 382
— sounds produced by flame, i. 329
— sulphuret of phosphorus, i. 414
and Stodart on alloys of nickel, ii. 241
—— carburets of iron, ii. 129
—— steel and platinum, ii. 296
—— —— silver, ii. 280
Fat, iii. 208
artificial, iii. 211
different kinds of, iii. 208

- *Fat lute*, ii. 324
- *Feathers*, iii. 207, 208
- *Febrifuge salt of Sylvius*, iii. 164
- *Fecula*, iii. 29
- *Fedler on gallic acid*, iii. 90
- *Feldspar*, blue, iii. 253
  - character of, iii. 252
  - used in pottery, iii. 252
  - green, iii. 253
  - varieties of, iii. 253
  - resplendent, iii. 253
  - composition of, iii. 253
  - Labradore, iii. 253
- *Feneulle on delphine*, iii. 74
- *Fermentation*, iii. 128
  - of beer, iii. 129
  - phænomena of, i. 178; iii. 128
  - products of, iii. 128
  - acetous, iii. 160
  - putrefactive, iii. 173
  - vinous, iii. 128, 130
- *Ferrane* (protochloride of iron), ii. 115
- *Ferranea*, (perchloride of iron), ii. 116
- *Ferri subcarbonas*, ii. 122
  - sulphas, ii. 119
- *Ferro-arsenical sulphuret of copper analyzed*, ii. 406
- *Ferro-chyazic acid*, ii. 125
- *Ferrocyanate of baryta*, ii. 125
  - cobalt, ii. 192
  - copper, ii. 160
  - iron, ii. 122
  - magnesia, ii. 125
  - potassa, ii. 124
  - soda, ii. 125
- *Ferrocyanates, metallic*, ii. 126
- *Ferro-prussiate of ammonia*, ii. 125
  - copper, ii. 160
  - iron, ii. 122
  - lime, ii. 125
  - potassa, ii. 124
  - —— used as a test, ii. 126
  - strontia, ii. 125
- *Ferro-prussic acid*, ii. 125
- *Ferrum ammoniatum*, ii. 117
  - tartarizatum, iii. 83
- *Ferruretted chyazic acid*, ii. 125
- *Fettstein*, ii. 316
- *Fibre*, iii. 42
- *Fibrine*, iii. 179, 202
  - of the blood, iii. 179
- *Filling up of lakes*, iii. 313
- *Fingal's Cave*, iii. 303
- *Fire*, i. 66
  - red, ii. 91
- *Fire-damp of coal-mines*, i. 442; iii. 293
- *Fish*, luminous before putrefaction, i. 305
  - air-bladders of, iii. 225
  - respiration of, iii. 225
  - scales of, iii. 214
- *Fixed air*, i. 44, 116, 129
  - Brownrigg, Dr., on, i 116
  - Cavendish on, i. 157
  - Priestley on, i. 129
  - obtained by Dr. Black, i. 116
- *Fixed alcalis*, ii. 13
  - nitre, ii. 43
  - oils, iii. 55, 208
  - sal ammoniac, ii. 63
- *Flake white*, ii. 185
- *Flame*, Davy on, i. 443
  - nature of, i. 303, 306
  - light of, i. 306
  - high temperature of, i. 306
  - extinction of by cooling, i. 307
  - extinguished by wire gauze, i. 30
  - production of sounds by, i. 329
  - coloured, iii. 145
- *Flammel, Nicholas*, i. 13
- *Flint glass*, ii. 299, 302
- *Flints*, ii. 307
  - liquor of (silicated alcali), ii. 29
- *Floetz rocks*, iii. 242
- *Flores martiales*, ii. 117
- *Flos ferri*, ii. 71
- *Flowers of plants*, structure of, iii. 4
- *Flowers of antimony*, ii. 174
  - benzoin, iii. 103

Flowers of plants, iii. 117
—— their colouring matter, iii. 117
sulphur, i. 386
zinc, ii. 134
Fluate of ammonia, ii. 75
lime, ii. 73, 373
Fluidity occasioned by heat, i. 243
Fluids, expansion of by heat, i. 225
of the animal body, iii. 188
bad conductors of heat, i. 237
compounds of solids and heat, i. 213
Fluoborate of ammonia, ii. 76
Fluoborates, ii. 76
Fluoboric acid, ii. 75, 512
Fluor, compact, ii. 74
spar, i. 198 ; ii. 73, 373
—— Scheele on, i. 167
—— phosphorescent, i. 304
Fluoric acid, ii. 73
obtained, ii. 74
its properties, ii. 74
— nature, ii. 74
— compounds, ii. 75
— decomposition, ii. 74
— tests in minerals, ii. 470
silicated, ii. 305
subsilicated, ii. 305
Fluorides, ii. 74
of calcium, ii. 74, 512
Fluorine, ii. 73
Fluosilicic acid, ii. 305
Flux, black, iii. 81
white, ii. 37
Fluxes, ii. 337
Foliated feldspar, iii. 253
Foot, cubic, of water, weight of, i. 338
Formation of veins, iii. 306
Formations, alluvial, iii. 242
primitive, iii. 242
secondary, iii. 242, 277
subordinate, iii. 243
transition, iii. 242
volcanic, iii. 245
Formic acid (from ants), iii. 350
Forms of matter, how modified, i. 192
bodies affected by heat, i. 238
crystals, i. 197
primitive of crystals, i. 198, 206
Fossil copal (Highgate resin)
Fossil remains, iii. 278, 295, 296, 297, 31
Fossils, magnesian, ii. 102
Fourcroy on ammonio-nitrate of magnesia
ii. 97
—— phosphate of soda, ii. 53
—— sulphate of magnesia, ii. 99
bones, iii. 215
chemical nomenclature, i. 183
fulminating mercury, iii. 158
hyposulphite of zinc, ii. 136
lactic acid, iii. 185
lupin seeds, iii. 120
onion, iii. 124
sulphate of mercury, ii. 256
Fowler's mineral solution, ii. 205
Fracture of gems, i. 197
Franklin on lightning conductors, i. 280
Fresh water formations, iii. 296
Freestone, iii. 295
Freezing, i. 241
mixtures, i. 120, 239
of water by ether, iii. 150
French nomenclature, i. 183
weights and measures, i. 459
Friar Bacon, i. 10
Friction, evolves light, i. 305
Frigorific mixtures, table of, i. 240
Frit, ii. 300
Frost bearer, i. 222, 247
Fruits, iii. 122
Fulhame on silvering silk, ii. 274
Fulminating gold, i. 166 ; ii. 286
mercury, iii. 157
platinum, ii. 294
powder, ii. 38
silver, ii. 269 ; iii. 158
Fumigation of infected places, iii. 174
Fuming liquor, Boyle's, i. 400
Libavius', ii. 142

Fuming sulphuric acid, i. 396
Functions, animal, iii. 216
Fungi, iii. 126
Fungic acid, iii. 108, 126
Fungin, iii. 41, 126
Furnaces, assay, i. xiii. xv.
  chemical, i. xiii.
  cupelling, i. xv.
  forge, i. xiv.
  Knight's, i. xv.
  reverberatory, i. xiii.
  sand, i. xiv. xv.
  wind, i. xiii. xv.
Fusibility of alloys, ii. 24
Fusible calculi, iii. 201
Fusible metal, ii. 24, 187
  salt, ii. 53, 337 ; iii. 194
Fusion, i. 194, 238
  of metals, ii. 11
Fyers, fall of, iii. 273

GADOLIN on yttria, ii. 330
Gadolinite, ii. 330, 482
Gahn on crystallization, i. 197
  manganese, ii. 3
Galena, ii. 167
  analysis of, ii. 412
Galibi, iii. 311
Galileo on the weight of air, i. 370
Gall stones, iii. 187
  of glass, ii. 301
Gallate of cinchonine, iii. 113
  iron, iii. 102
  lead, iii. 100
Gallic acid, iii. 98, 349
  obtained, iii. 99
  its properties, iii. 100
  — composition, iii. 100
  — use as a test, iii. 100
  — combinations with metals, iii. 101
  table of its metallic precipitates, iii. 101
Galls, iii. 98, 103
Galls, tincture of, i. 142
  —— used as a test, i. 142 ; ii. 490
  infusion of, iii. 100
Galvani, notice of his discoveries, i. 186
Galvanic apparatus, i. 187, 269
  arrangements, i. 269
  battery, i. 272
  circle, i. 270
  pile, i. 187, 270
  —— theory of its action, i. 279
Galvanism, chemical agencies of, i. 269
  effects of, i. 272
  excitement of, i. 268
  theory of, i. 279
Gamboge, iii. 66
Gangue, iii. 305
Garlic, iii. 124
Garnet, black, ii. 314
  common, ii. 314
  noble, ii. 314
  precious, ii. 314
  white, ii. 314
Garnet, Dr., on granitic breccia, iii. 273
Gas, i. 176
  mentioned by Van Helmont, i. 44
  expansion of, by heat, i. 226
  illumination, economy of, i. 440
  tubes, i. 313
  lighting, i. 439
  apparatus, i. xiv. 439
  holder, i. 314
  —— for hydrogen, i. 328
  jars, i. 313
  ammoniacal, i. 361, 466
  arseniuretted hydrogen, ii. 211
  azotic, i. 346
  bi-phosphuretted hydrogen, i. 410
  carbonic acid, i. 422
  —— oxide, i. 420
  carburetted hydrogen, i. 435, 438
  chlorine, i. 318, 464
  chlorocarbonic, i. 421
  coal, i 439
  euchlorine, i. 320, 464

Gas, fluoboric, ii. 76, 512
hydriodic acid, i. 345
hydrocarburetted, i. 438
hydrochloric, i. 341
hydrophosphoric, i. 412, 468
hydrogen, i. 326
muriatic acid, i. 220, 341, 465
nitric oxide, i. 349, 465
nitrogen, i. 346, 465
nitrous, i. 349, 465
nitrous acid, i. 351, 465
—— etherized, iii. 155
—— oxide, i. 347, 465
oil, i. 441
olefiant, i. 435
oxygen, i. 311, 464
oxymuriatic acid, i. 318
percarburetted hydrogen, i. 435
phosgene, i. 421
phosphuretted hydrogen, i. 411, 468
potassiuretted hydrogen, ii. 36
seleniuretted hydrogen, ii. 202, 441
silicated fluoric acid, ii. 305
silvestre, i. 44
sulphuretted hydrogen, i. 398, 467
sulphurous acid, i. 388
telluretted hydrogen, ii. 200
from coal, i. 439
—— oil, i. 441
—— ponds, i. 438
Gases, Lavoisier on, i. 174
described, i. 285
absorption of, by carbon, i. 418
—— water, i. 339
mixture of, analyzed, i. 445
bad conductors of heat, i. 237
combine in definite volumes, i. 220
discovery of, its influence on chemistry, i. 99
effects of pressure on, i. 234, 370
expansion of, by heat, i. 225
heat by compression, i. 234
mixture of, i. 329
produce a solid by combining, i. 214
Gases produce a liquid by combining, i. 214
rules for correction of their volumes, i. 375
solutions of, i. 340
sounds produced by, i. 329
specific gravity of, i. 379
transferred, i. 374
volume of, corrected for temperature, i. 375
—— pressure, i. 375
weighed, i. 374
weights of, i. 379
of mineral waters ascertained, ii. 491
Gasometer, i. 314
Gastric juice, iii. 217
Guadaloupe skeletons, iii. 311
Gauze, wire, extinction of flame by, i. 307
Gay-Lussac and Biot, their ascent in a balloon, i. 160
his ascent in a balloon, i. 160
— eudiometer, i. 381
on air in water, i. 339
— albumen, iii. 179
— alcohol in vapour, iii. 136, 147
— alloys of arsenic, ii. 215
— analysis of vegetable substances, iii. 12
— arsenuretted hydrogen, ii. 212
— borurets, ii. 22
— chloric acid, i. 322
— chlorocyanic acid, i. 448
— chloride of silver, ii. 271
— compounds of tin, ii. 141
— crystallization of lime, ii. 61
— cyanogen, i. 446
— decomposition of water by iron, ii. 113
— definite proportions, i. 85
— ether in vapour, iii. 149
— ferro-prussic acid, ii. 125
— hydriodic ether, iii. 160

Gay-Lussac on hyposulphite of strontian, ii. 92
— iodate of soda, ii. 50
— iodide of sulphur, i. 308
— iodine, i. 324
— muriatic acid, i. 61, 341
— oxide of iron, ii. 113
— oxalic acid, iii. 17
— pernitrous acid, i. 350
— potassium, ii. 28
— prussic acid, i. 171
— starch, iii. 17, 33
— sulphovinate of baryta, iii. 154
— vapour of alcohol, iii. 136
— —— ether, iii. 149
— vegetable substances, iii. 16
— wax, iii. 54
Gasometer, mercurial, i. 320
Geber the alchemist, i. 8
Gelatine, iii. 203
artificial, iii. 179
its properties, iii. 203
— tests, iii. 204
— conversion into sugar, iii. 204
— varieties, iii. 205
Gellert, i. 79
Gems, ii. 312
artificial, ii. 304
General laws of chemical changes, i. 191
Gentian, iii. 112
Geoffroy, i. 54
his tables, i. 78
Geological specimens, English catalogue of, iii. 251
Geological theories, Buffon's, iii. 238
Burnet's, iii. 231
Hutton's, iii. 243, 255
Leibnitz's, iii. 236
Werner's, iii. 242, 257
Whiston's, iii. 237
Whitehurst's, iii. 237
Woodward's, iii. 235
Geology, iii. 229
general remarks on, iii. 230
Germination, iii. 5
Giant's Causeway, iii. 302
Gilding on porcelain, ii. 291, 322
steel, ii. 287; iii. 150
—— by ethereal solution, ii. 287; iii. 150
water, ii. 291
Gilpin on the specific gravity of water at different temperatures, i. 462
diluted alcohol, iii. 137
Gilpin's tables, iii. 138
Gin, iii. 135
Glacial phosphoric acid, i. 406
sulphuric acid, i. 35, 396
Glance coal, iii. 77
silver, ii. 276
Glaser's polychrest salt, ii. 38
Glass, its nature, ii. 298
how made, ii. 300
its composition, ii. 302
a nonconductor of electricity, i. 254, 262
transmits radiant matter, i. 296
partially intercepts terrestrial radiant heat, i. 296
corroded by fluoric acid, ii. 75
antimonial, ii. 178
coloured, ii. 304
—— by manganese, ii. 110
crown, ii. 303
engraved, ii. 75
flint, ii. 299, 302
furnace, ii. 300
gall, ii. 301
green bottle, ii. 303
phosphoric, i. 406
plate, ii. 303
soap, ii. 299
Glauber, i. 45, 46, 97
describes volatile alcali, i. 47
—— sulphate of ammonia, i. 47
—— sal ammoniac, i. 47
—— sulphate of copper, i. 47
—— vinegar from wood, i. 47

Glauber describes muriatic acid, i. 47; ii. 50
—— sulphate of soda, i. 47
improves chemical apparatus, i. 51
his mode of heating by steam, i. 51
on nitre, ii. 37
Glauberite, ii. 68
Glauber's salt, i. 47, 49; ii. 51
Gliadine, iii. 36
Globules of the blood, iii. 180
Glowing lamp, i. 307
Glow-worm, i. 305
Glucina, obtained, ii. 329, 479
its properties, ii. 328
— compounds analyzed, ii. 479
— sulphate, ii. 481
Glucinum, ii. 329
Glue, iii. 205
Gluten, iii. 35
obtained, iii. 35
its properties, iii. 35
— proportion in different vegetables, iii. 37
analyzed, iii. 36
vegetable, iii. 36
Gmelin on phosphate of lithia, ii. 59
Gneiss, iii. 254
Gold, ii. 283, 512
obtained pure, ii. 283
analysis of ores of, ii. 467
—— alloys of, ii. 290, 467
purple powder produced from, ii. 143, 287
fulminating, i. 166; ii. 286
graphic, ii. 436
Manheim, ii. 161
mosaic, ii. 144
native, ii. 283
powder, ii. 291
standard, ii. 290
its alloys, ii. 287
— amalgam, ii. 291
— assay, ii. 291
— chemical qualities, ii. 284
Gold, its chloride, ii. 284, 542
— ductility, ii. 283
— ethereal solution, ii. 287; iii. 1
— fineness, ii. 290
— imitations, ii. 295
— iodide, ii. 284, 542
— malleability, ii. 283
— muriate, ii. 284, 285, 542
— —— with potassa, ii. 285
— nitrate, ii. 285, 542
— oxide, ii. 284, 542
— phosphuret, ii. 287, 543
— physical properties, ii. 283
— purification, ii. 283, 286
— solution in ether, ii. 287; iii.
— —— potassa, ii. 285
— solvents, ii. 285
— sulphate, ii. 287
— sulphuret, ii. 287, 542
— tests, ii. 287, 542
and antimony, ii. 290
— arsenic, ii. 290
— bismuth, ii. 290
— cobalt, ii. 290
— copper, ii. 290
— iron, ii. 288
— lead, ii. 288
— nickel, ii. 289
— tin, ii. 288
— zinc, ii. 288
Golden sulphuret of antimony, ii. 179
Goniometer, description and use of, i. 19
Wollaston's, i. 200
Goulard's extract, iii. 169
Granite, its component parts, iii. 251
its localities in England, iii. 269
— aspects, iii. 254, 258
— height, iii. 276
— origin, iii. 255
— position, iii. 255
— veins, iii. 256, 257
— decomposition, iii. 259, 271, 309
Granite, porphyritic, iii. 260
slaty, iii. 254

Granite, boulders, iii. 270
  tors, iii. 272
Granitic breccia, iii. 273
  conglomerate, iii. 273
Granular limestone, ii. 71; iii. 265
Grape juice, iii. 130
Graphic ore, ii. 199, 436
Graphite, ii. 121
Grauwacke, iii. 281, 282
  slate, iii. 281
Gravel, iii. 297
  urinary, iii. 199
Gravitation, i. 192
Gravity, specific, ii. 6
  of fluids, ii. 7
  — gases, i. 464
  — solids, ii. 6
  how ascertained, ii. 6
  affected by heat, i. 227
  of diluted alcohol, iii. 137
  — ammonia, i. 361
  — nitric acid, i. 356
  — muriatic acid, i. 342
  — sulphuric acid, i. 392
Green dye, iii. 52
Green, Brunswick, iii. 84
  feldspar, iii. 253
  sap, iii. 123
  Scheele's, i. 168; ii. 206
  tourmaline, ii. 471
  vitriol, ii. 119
Greenstone, iii. 298
Gregor on titanium, ii. 4
  on uranite, ii. 429
Grenatite, analysis of, ii. 315
Grey cast-iron, ii. 127
  dye, iii. 48
  ore of tellurium analyzed, ii. 436
Growth of plants, iii. 2, 5
Guaiacum, iii. 65
Guibourt, on sulphuret of mercury, ii. 254
Gum, iii. 18, 345
  its properties, iii. 19
Gum arabic, iii. 19
  British, iii. 34
  cherry-tree, iii. 20
  elastic, iii. 36
  formed from sugar, iii. 28
  —— starch, iii. 34
  —— wood, iii. 42
  tragacanth, iii. 20
  tests for, iii. 19
  composition of, iii. 17, 20
Gummate of lead, iii. 19, 345
Gum resins, iii. 66
Gunpowder, i. 11, 12; ii. 38
  its discovery attributed to Roger Bacon, i. 11
  —— Bartholomew Schwartz, i. 12
  date of its use, i. 12
  its composition, ii. 38
  — analysis, ii. 353
  — varieties, ii. 38
  — products when burned, ii. 30
  made with chlorate of potassa, ii. 34
  preparation of charcoal for, i. 417; iii. 162
Guyton Morveau, on alloys of lead, ii. 172
  on nomenclature, i. 183
  — tungstic acid, ii. 226
Gymnotus, i. 282
Gypsum, ii. 67; iii. 290
  granular, ii. 67
  anhydrous, ii. 67; iii. 290

HÆMATITE, ii. 114
  analysis of, ii. 383
Hair, its nature, iii. 208
  salt, ii. 98
Hales, i. 100
  the founder of pneumatic chemistry, i. 99
  on respiration, i. 102
  — vegetation, i. 104

Hall, Sir J., on basalt, iii. 300
Halley, graduation of thermometers, by, i. 89
Hard metals, list of, ii. 10
waters, i. 336; iii. 57
—— test for, i. 145; iii. 57
Harmotome, analysis of, ii. 319, 375
Harrowgate water, ii. 502
Hartshorn, salt of, iii. 173
spirit of, iii. 173
Hatchetine, iii. 76 (mineral adipocere),
Hatchett, on albumen, iii. 179
on alloys of antimony, ii. 182
gold, ii. 288
antimony, ii. 173
artificial tannin, iii. 45
benzoic acid, iii. 103
bismuth, ii. 184
bitumen, iii. 75
bone, iii. 212
Bournonite, ii. 418
camphor, iii. 62, 64
columbite, ii. 454
columbium, ii. 4, 229, 454
ferrocyanate of copper, ii. 160
gelatine, iii. 203, 205
hair, iii. 208
indigo, iii. 50
iron pyrites, ii. 119
lac, iii. 65
magnetic pyrites, ii. 384
molybdate of lead, ii. 450
molybdenum, ii. 218
phosphuret of iron, ii. 120
resins, iii. 64
retinasphaltum, iii. 76
separation of iron and manganese, ii. 104, 381
shell, iii. 212
sinovia, iii. 190
tannin, iii. 45
Hauy's theory of crystallization, i. 197
— modification of it by Dr. Wollaston, i. 208
Hauy on minute quantities of magnetism, ii. 336
Heart-wood, iii. 3
Heat, general observations on, i. 223
opposed to attraction, i. 223
expands bodies, i. 224
expansion of air by, i. 226
—— alcohol by, i. 225
—— liquids by, i. 224
—— mercury by, i. 225
—— solids by, i. 224
—— water by, i. 225
the cause of vapour, i. 241
affects chemical affinity, i. 216
—— specific gravity, i. 227
production of electricity by, i. 254
conducting power of bodies for, i. 235; ii. 5
badly conducted by fluids, i. 237
conductors of, i. 235; ii. 5
metals, conductors of, i. 235; ii. 5
loss of in change of state, i. 239
—— vaporization, i. 244
—— solution, i. 120, 239
capacity of bodies for, i. 233
influence of on the forms and states of bodies, i. 174, 238
operation of radiant matter in producing, i. 293, 308
modes of measuring sensible, i. 229
—— latent, i. 233
measures of, i. 229
radiators of, i. 298
receivers of, i. 298
sensation of, i. 238, 296
of flame, i. 306, 330
— steam employed to warm buildings, i. 245
— plants, iii. 8
Black on, i. 117
Lavoisier on, i. 174
Scheele on, i. 163, 164
its absorption, i. 239

Heat, its absorption during evaporation, i. 122, 243, 247
— —— gasification, i. 243
— —— liquefaction, i. 120, 239
— action on metals, ii. 11
— conduction, i. 234, 238
— effects ascribed to a substance, i. 248
— —— to motion, i. 248
— evolution by compression, i. 234
— —— animal life, iii. 225
— —— solidification, i. 241
— —— vegetation, iii. 8
— —— chemical action, i. 214
— motion, i. 164, 235, 293, 308
— nature, i. 248, 297, 308
— phenomena explained by motion, i. 297, 308
— radiation, i. 93, 164, 293, 308
— reflection, i. 93, 164, 294
— refraction, i. 93, 165, 294
animal, iii. 225
combined, i. 239
insensible, i. 239
latent, i. 117, 239
—— quantity of in water, i. 239
—— —— vapour, i. 244
radiant, i. 164, 293, 308
—— solar, i. 293
—— terrestrial, i. 296
—— theory of, i. 297, 308
specific, i. 232
—— formula for ascertaining, i. 232
Heating by steam, i. 245, 246
Heavy spar, ii. 84
Hecht on titanium, ii. 196
tungstates, ii. 227
Height of primitive mountains, iii. 268
Heliotrope, ii. 307
Hellot's sympathetic ink, ii. 189
Helmont, *Van*, i. 17
Helvetius, his relation of a transmutation, i. 19
Henbane, iii. 116
Henley's electrometer, i. 260
Hematine, iii. 39
Henry on alkalimetry, ii. 44, 353
ammonia, i. 362
bark of horse-chestnut tree, iii. 114
coal gas, i. 442
diabetic urine, iii. 198
eudiometry, i. 382
gentian, iii. 112
uric acid, iii. 192
weighing of gases, i. 374
Hepars (alkaline sulphurets)
Hepatic air, i. 398
Hermann on coffee, iii. 120
Hermes, *Trismegistus*, i. 6
works attributed to him, i. 7
Herschel, *Sir W.*, *on radiant heat*, i. 293
Herschel, *Mr.*, on hydrosulphuret of lime, ii. 65
hyposulphites, ii. 17
hyposulphite of baryta, ii. 83
—— copper, ii. 156
—— lime, ii. 65
—— silver, ii. 276
—— strontia, ii. 92
Hessian crucibles, ii. 323
Hielm on molybdenum, ii. 4, 218
Hierne, the analyst, i. 141
Higgins, i. 84, 219
Hill's new process for obtaining sulphuric acid, i. 396
Himáláyá mountains, iii. 268, 276
Hisinger on cerium, ii. 4, 197
History of chemistry, i. 1
alchymy, i. 6
analytical chemistry, i. 141
the theory of combustion, i. 59
Hoffman on magnesia, i. 115
Homberg, i. 54
discovered boracic acid, i. 54
—— pyrophorus, i. 54
Homberg's phosphorus, ii. 63
pyrophorus, i. 54, 166; ii. 310

- *Homberg's sedative salt*, i. 464
- *Home, Sir E.*, on digestion, iii. 218
  - on the bile, iii. 220
  - — animal functions, iii. 227
  - — the proteorhachius, iii. 295
- *Homogeneous attraction or affinity*, i. 192
- *Honey*, iii. 27
  - stone, iii. 77
- *Hooke*, i. 57, 97
  - his views of combustion, i. 59, 62, 130
- *Hope on carbonate of strontia*, ii. 93
- *Hope's eudiometer*, i. 382
- *Hordein*, iii. 34
- *Horn*, iii. 207
  - lead, ii. 165
  - silver, ii. 270
  - blende, iii. 261
- *Horse-chestnut-tree bark*, iii. 114
- *House-leek*, malic acid from the, iii. 97
  - thunder, i. 281
- *Howard on fulminating mercury*, iii. 157
  - meteoric stones, ii. 240
- *Hulme on phosphorescent bodies*, i. 305
- *Humboldt on the air in water*, i. 339
- *Humours of the eye*, iii. 189
- *Hundred-legged worm, luminous*, i. 305
- *Hutton on radiant heat*, i. 293
  - curved lime-stone strata, iii. 284
  - coal strata, iii. 293
  - on the theory of the earth, iii. 243, 255
- *Huygens on radiation*, i. 285
- *Hyacinth*, ii. 326, 478
  - of Compostella, ii. 307
- *Hydrargillite*, ii. 312
- *Hydrargyri nitrico-oxydum*, ii. 254
  - oxydum cinereum, ii. 243
  - —— rubrum, ii. 243
  - oxymurias, ii. 248
  - præcipitatum album, ii. 251
  - submurias, ii. 244
  - sulphuretum nigrum, ii. 254
  - —— rubrum, ii. 255
- *Hydrargyrum*, ii. 242
- *Hydrate, what*, i. 339
- *Hydrate of alumine*, ii. 209
  - baryta, ii. 77, 512
  - cobalt, ii. 188
  - copper, ii. 149, 153
  - lime, ii. 61, 510
  - magnesia, ii. 515
  - manganese, ii. 105
  - nickel, ii. 232, 535
  - potassa, ii. 30, 505
  - —— its properties, ii. 32
  - soda, ii. 48, 507
  - strontia, ii. 89, 514
  - tin, ii. 140
- *Hydrated bi-carbonate of ammonia*, i. 43
  - carbonate of ammonia, i. 432
  - oxides, ii. 15
  - sulphuric acid, i. 391
- *Hydrates*, metallic, i. 339; ii. 15
- *Hydriodate of ammonia*, i. 367, 466
  - baryta, ii. 82, 513
  - gold, ii. 542
  - iron, ii. 117
  - lime, ii. 511
  - magnesia, ii. 97, 515
  - mercury, ii. 537
  - metals, ii. 14
  - platinum, ii. 541
  - potassa, ii. 35, 505
  - silver, ii. 540
  - soda, ii. 508
  - strontia, ii. 91
  - tellurium, ii. 200
  - zinc, ii. 135, 520
- *Hydriodic acid*, i. 345, 465
  - —— its composition, i. 346
  - ether, iii. 160
  - gas, i. 345, 465
  - —— soluble in water, i. 345
- *Hydriodide of carbon*, i. 438, 469
- *Hydro-boracic acid*, i. 453, 470
- *Hydro-carburet*, i. 435
- *Hydro-chloric acid*, i. 341
  - gas, i. 341

Hydro-chlorates (see *Muriates*)
Hydro-chloride of carbon, i. 437, 469
Hydro-cyanate of iron, ii. 122
potassa, ii. 46
Hydro-cyanic acid, i. 449, 470
Hydro-fluate of ammonia, ii. 75
potassa, ii. 75, 306
soda, ii. 75
Hydro-fluoric acid, ii. 73, 511
its properties, ii. 74
— composition, ii. 75
Hydrogen, i. 177, 326, 464
its absorption by charcoal, i. 419
— combination with carbon, i. 435, 469
— —— chlorine, i. 341, 465
— —— fluorine (fluoric acid), ii. 73
— —— iodine, i. 344, 465
— —— metals, ii. 15
— —— nitrogen, i. 361, 466
— —— oxygen, i. 330, 464
— —— phosphorus, i. 410, 468
— —— sulphur, i. 398, 467
— combustion, i. 327, 331
— explosion with air, i. 327
— —— oxygen, i. 329
— flame, heat of, i. 330
— peroxide, i. 339; ii. 78
— preparation, i. 326
— properties, i. 158, 327
— purity ascertained, i. 381
— refraction, i. 288
— weight, i. 158, 327
an element of water, i. 330
with oxygen forms water, i. 330
and chlorine, i. 341
— —— explode by sunlight, i. 301, 341
— carbon, i. 435
— cyanogen, i. 449
— iodine, i. 345
action of on metals, i. 15
—— potassium, ii. 36
eudiometer, i. 380
Hydrogen, arsenuretted, ii. 211
bi-carburetted, i. 436
bi-phosphuretted, i. 410
carburetted, i. 435
percarburetted, i. 435
phosphuretted, i. 410
potassuretted, ii. 36
seleniuretted, ii. 202, 441
sulphuretted, i. 166, 398, 467
—— combined with alcalis, i. 399; ii. 39, 50
—— —— earths, ii. 65, 83, 91
supersulphuretted, i. 401
telluretted, ii. 200
gas obtained by Hales, i. 102
—— —— Mayow, i. 71
—— Cavendish on, i. 156, 326
—— sounds produced by, i. 329
—— recommended for balloons by Dr. Black, i. 158
—— —— Cavallo, i. 158
—— holder, i. 328
Hydroguret of carbon, i. 435
phosphorus, i. 410
Hydrogurets, metallic, ii. 15
Hydroguretted sulphur, i. 401
sulphurets, ii. 19
—— of metals, ii. 19
—— — antimony, ii. 179
Hydroionic acid (hydriodic acid), i. 345
Hydrometer, iii. 129, 137
Hydro-nitric acid, i. 355
Hydro-oxides (hydrates),
Hydro-oxide of cobalt, ii. 188
copper, ii. 149
nickel, ii. 232
Hydrophane, ii. 307
Hydro-phosphoric gas, i. 412, 468
its properties, i. 412
— composition, i. 413
Hydro-phosphorous acid, i. 404, 410, 468
decomposition of, i. 413
Hydro-phosphuret of lime, ii. 68
Hydro-pneumatic apparatus, i. 312

Hydro-sulphuret of ammonia, i. 399, 467
—— used as a test, ii. 20
antimony, ii. 179
baryta, ii. 83
lead, ii. 169
lime, ii. 65
potassa, ii. 39
soda, ii. 50
strontia, ii. 91
tin, ii. 145
Hydro-sulphuretted oxide of antimony, ii. 179
bismuth, ii. 186
cobalt, ii. 191
lead, ii. 169
nickel, ii. 235
tin, ii. 145
Hydro-sulphuretted oxides, ii. 19
Hydro-sulphuric acid, i. 398
Hydrothionic acid, i. 398
Hydruret of arsenic, ii. 211
metals, ii. 15
potassium, ii. 36, 505
tellurium, ii. 200
Hygrometer, i. 385
Daniell's, i. 385
De Luc's, i. 385
Saussure's, i. 385
Wilson's, i. 385
Hygrometric powers of sulphuric acid, i. 390
water, i. 385
Hygroscopes, i. 385
Hyoscyama, iii. 117
Hyper-oxymuriates (chlorates)
Hypo-nitrous acid, i. 351
Hypo-phosphite of baryta, ii. 87
lead, ii. 169
lime, ii. 68
magnesia, ii. 99
manganese, ii. 109
potassa, ii. 42
soda, ii. 52
strontia, ii. 92
Hypo-phosphoric acid (phosphatic acid), i. 407
Hypo-phosphorous acid, i. 404, 467
Hypo-sulphate of baryta, ii. 84
Hypo-sulphates, metallic, ii. 18
Hypo-sulphite of ammonia, ii. 66
baryta, ii. 66, 88, 513
copper, ii. 156, 524
lead, ii. 168
lime, ii. 65, 511
magnesia, ii. 97, 516
manganese, ii. 108, 517
mercury, ii. 256
metals, ii. 17
potassa, ii. 40, 66, 506
silver, ii. 276
—— and potassa, ii. 277
soda, ii. 51, 66, 508
strontia, ii. 514
tin, ii. 145
zinc, ii. 136, 521
Hypo-sulphuric acid, i. 387 ; ii. 84
Hypo-sulphurous acid, i. 387, 466

ICE, its properties, i. 336
lighter than water, i. 338
specific gravity of, i. 338
produced by evaporation, i. 123
quantity of heat absorbed by in liquefaction, i. 239
Iceland crystal, i. 289
moss, iii. 125
spar, i. 289; ii. 70
Idocrase, ii. 314
Igasurate of strychnia, iii. 73
Igasuric acid, iii. 73
Ignition, i. 306, 308
of air, i. 305
by combustion without flame, i. 306
Illumination by gas, i. 439
economy of, i. 440
Imponderable matter, i. 285
Incandescence, i. 306

Incandescent bodies, phænomena of, i. 303
Inch cubic of water, weight of, i. 338
Indelible ink, ii. 275
Indian ink, iii. 103
Indian steel, ii. 130
  analysis of, ii. 387
Indications of metallic veins, iii. 307
Indigo, iii. 48
  analyzed, iii. 49
Indigogene (sublimed indigo), iii. 48
Induction, electrical, i. 255, 258, 264
Infectious atmosphere, fumigation of, iii. 174
Inflammability of ether, iii. 151
Inflammable air, Cavendish on, i. 157, 326
  fossils, iii. 75
  lamp, Volta's, i. 330
  pistol, i. 327
  substances, simple, i. 326
  —— positive electrical state of, i. 274
Inflammation by electricity, i. 268
Ink, iii. 102
  Indian, iii. 103
  indelible, ii. 275
  printers', iii. 56
  receipt for, iii. 102
  sympathetic, muriate of cobalt, ii. 189
  —— nitrate of bismuth, ii. 186
Insensible heat, i. 239
Institution, *Royal*, voltaic battery of the, i. 272
  laboratory of the, i. xiii.
Insulators, *electrical*, i. 253
Inulin, iii. 41
Integral elements of crystals, i. 207
Intensity of electricity, i. 266, 276
Iodate of ammonia, i. 365, 466
  baryta, ii. 82, 513
  bismuth, ii. 185
  copper, ii. 153
  iron, ii. 117
Iodate of lead, ii. 166, 526
  lime, ii. 64
  mercury, ii. 252
  potassa, ii. 35, 505
  silver, ii. 273
  soda, ii. 50, 508
  strontia, ii. 91, 514
  tin, ii. 144
  zinc, ii. 135, 520
Iodic acid, i. 324
  its action on metals, ii. 15
Iodide of antimony, ii. 177, 527
  arsenic, ii. 211, 531
  barium, ii. 82, 513
  bismuth, ii. 185, 528
  calcium, ii. 511
  cobalt, ii. 190
  copper, ii. 152, 524
  gold, ii. 284, 542
  iron, ii. 117, 519
  lead, ii. 166, 526
  lithium, ii. 58
  magnesium, ii. 97
  mercury, ii. 252, 537
  nickel, ii. 233, 536
  nitrogen, i. 360, 466
  phosphorus, i. 410
  platinum, ii. 544
  potassium, ii. 35, 505
  silver, ii. 272, 540
  sodium, ii. 50, 508
  starch, iii. 30
  strontium, ii. 91, 514
  sulphur, i. 398
  tellurium, ii. 200
  tin, ii. 143, 522
  zinc, ii. 135, 520
Iodides, metallic, ii. 14
Iodine, i. 309, 323, 464
  discovery of, i. 324
  obtained, i. 323
  its properties, i. 324
  is electro-negative, i. 324
  forms a violet vapour, i. 324

Iodine, action of alcalis on, ii. 35
—— euchlorine on, i. 325
its nitruret, i. 360, 466
— phosphuret, i. 410
— sulphuret, i. 398
— compounds with chlorine, i. 325, 464
— —— cyanogen, i. 449
— —— hydrogen, i. 344, 465
— —— metals, ii. 14
— —— nitrogen, i. 360, 466
— —— oxygen, i. 324, 464
— —— phosphorus, i. 410, 468
— —— sulphur, i. 398, 467
tested by starch, iii. 30
Iodo-sulphuric acid, i. 396
Iodures (iodides) ii. 14
Iodurets (iodides) ii. 14
Ipecacuanha, iii. 109
active principle of, iii. 41
Iridium, ii. 4, 263
its discovery, ii. 263
— properties, ii. 263
Iron, ii. 110, 518
processes of working it, ii. 128
analysis of ores of, ii. 383
decomposition of water by, i. 335; ii. 113
not the cause of the red colour of blood, iii. 181
tinning of, ii. 127
and alumine, ii. 308
— gold, ii. 288
— nickel, ii. 236
ammoniated, ii. 111
cast, ii. 127
— contains silicium, ii. 306
crude, or pig, ii. 127
malleable, or bar, ii. 128
meteoric, ii. 110, 238
native, ii. 110
ores clay ironstone, ii. 114; iii. 294
— hematite, ii. 114
— magnetic, ii. 114
Iron ores, micaceous, ii. 114
— smelting of, ii. 115
pyrites, ii. 118
stone, argillaceous, ii. 114; iii. 2
tartarized, iii. 82
wrought, ii. 128
its acetates, iii. 165, 350
— alloys, ii. 127, 236
— arseniate, ii. 209, 532
— benzoate, iii. 105
— borate, ii. 127
— carbonate, ii. 122, 519
— —— native, ii. 122
— carburet, i. 168; ii. 121, 129
— chlorides, ii. 115, 518
— —— analyzed, ii. 384
— chromate, ii. 222, 534
— —— analyzed, ii. 452
— citrate, iii. 349
— combustion, ii. 111
— —— in chlorine, ii. 116
— compounds analyzed, ii. 383
— expansion by heat, i. 224
— ferrocyanate, ii. 122
— ferroprussiate, ii. 122
— gallate, iii. 102
— hydriodates, ii. 117
— hydrocyanates, ii. 122
— iodides, ii. 117, 519
— muriates, ii. 116, 518
— native state, ii. 110, 238
— nitrates, ii. 117, 519
— ores, ii. 114
— —— assay of, ii. 383
— oxalates, iii. 90, 348
— oxides, ii. 111, 346, 518
— —— their composition, ii. 112
— —— analyzed, ii. 383
— oxyphosphate, ii. 121, 519
— oxysulphate, ii. 120, 519
— phosphate, ii. 120, 519
— phosphuret, ii. 120, 519
— —— analyzed, ii. 387
— peracetate, iii. 165

Iron, its peroxalate, iii. 90
- — peroxide, ii. 112, 518
- — preparation, ii. 115
- — properties, ii. 110
- — protacetate, iii. 165
- — protoxalate, iii. 90
- — protoxide, ii. 111, 518
- — salts, ii. 115, 127, 518
- — separation from manganese, ii. 104, 381, 382
- — structure, ii. 128
- — succinate, iii. 68, 346
- — sulphate, ii. 119, 519
  - — —— analyzed, ii. 384
  - — —— with nickel, ii. 235
- — sulphuret, ii. 118, 519
  - — —— analyzed, ii. 386
- — supersulphuret, ii. 118, 519
- — tanno-gallate, iii. 102
- — tartrate, iii. 82, 347
  - — —— with potassa, iii. 83, 347
- — tests, i. 142, 151; ii. 127, 346, 490, 518
- — tincture, ii. 117
- — tungstate, ii. 228
- — use as a test, ii. 127
- — varieties, ii. 127

Iserine, ii. 196

Isinglass, iii. 205

Ittria (yttria) ii. 330

Ivory, iii. 215
- black, iii. 216

JADE, ii. 316

Jalap, iii. 111

James's powder, composition of, ii. 180

Jar, electrical, i. 259
- theory of, i. 261

Jargon, ii. 326, 478

Jars for gases, i. 312

Jasper ware, Wedgewood's, ii. 85

Jeffries on diamonds, i. 415

Jelly, iii. 203

Jelly, chemical properties of, iii. 203
- animal, iii. 203

John, Dr., on the analysis of needle ore, ii. 423
- on cochineal, iii. 51
- — laccic acid, iii. 66
- — medullin, iii. 43
- — succinate of manganese, iii. 68
- — wax, iii. 54

Joints, fluid in the cavities of the, iii. 190

KALI (potassa), ii. 43

Kater on the seconds' pendulum, i. 458
- on the French metre, i. 459

Keill on Burnet's theory of the earth, iii. 233

Keir on the solution of silver, ii. 278

Kelp, ii. 53
- the alcali in, ascertained, ii. 354
- iodine obtained from, i. 323

Kermes mineral, ii. 179

Kilburn waters, ii. 502

Killas, iii. 281

Kinate of lime, iii. 108

Kinates, iii. 108

Kinic acid, iii. 108

Kirchoff on conversion of starch into sugar, iii. 32

Kirwan on specific gravity of mineral waters, ii. 488

Klaproth on antimonial ores, ii. 416
- on baryta, ii. 375
- — bell-metal ore, ii. 399
- — black sulphuret of copper, ii. 405
- — cyanite, ii. 317
- — datolite, ii. 471
- — dolomite, iii. 266
- — emerald, ii. 479
- — harmotome, ii. 319
- — hyacinth, ii. 326
- — kryolite, ii. 477
- — lepidolite, ii. 317

Klaproth on leucite, ii. 314
  — mellilite, iii. 77
  — moroxylic acid, iii. 107
  — murio-carbonate of lead, ii. 415
  — pechblende, ii. 429
  — pharmacolite, ii. 447
  — phosphate of copper, ii. 409
  — —— lead, ii. 413
  — silver ores, ii. 460
  — spinelle, ii. 472
  — steatite, iii. 265
  — sulphate of lead, ii. 412
  — tellurium ores, ii. 434
  — tin ores, ii. 396
  — titanium ores, ii. 431
  — tungstate of lime, ii. 452
  — tungstic acid, ii. 227
  — ulmin, iii. 38
  — uranium, ii. 4, 193
  — zirconia, ii. 478
Knight's furnace, i. xv.
Knight on the motion of sap in plants, iii. 8
Koumiss, iii. 185
Koupholite, ii. 315
Krameric acid, iii. 108
Kryolite analyzed, ii. 472
Kunckel, i. 45

LABORATORY of the Royal Institution, i. xiii.
Labrador feldspar, iii. 253
Lac, iii. 65
  stick, iii. 65
  seed, iii. 65
  shell, iii. 65
  analysis of, iii. 65
Laccate of lead, iii. 66
Laccates, iii. 66
Laccic acid, iii. 65, 66
Lactic acid, i. 169 ; iii. 185
Lagrange on senna, iii. 116
Lake, iii. 51
Lakes, filling up of, iii. 313
Lamp, miners' safety, i. 307, 443 ; iii.
  inflammable air, i. 330
  glowing, i. 307
  black, i. 418
Lampadius on carburet of sulphur, i. 45
  native oxide of bismuth, ii. 428
Lampates, iii. 155
Lampic acid, iii. 154
  properties of, iii. 154
Lançon on paste for artificial gems, ii.
Lana philosophica, ii. 134
Lane, i. 141
Lantern fly, i. 305
Lapis infernalis, ii. 273
  lazuli, analysis of, ii. 318
Laplace on specific heat, i. 233
Lard, iii. 208
Lassaigne on Delphine, iii. 74
Latent heat, i. 117, 239
  of water, i. 239
  — vapour, i. 244
Laugier on meteoric stones, ii. 241
  sulphurets of arsenic, ii. 214
Laumonite, ii. 313
Lavoisier opposed to the phlogistic the i. 67
  his theory of combustion, i. 67
  notice of his researches, i. 172
  on aëriform bodies, i. 174
  — apparatus, i. 181
  — the atmosphere, i. 175
  — caloric, i. 174
  — combustion, i. 176, 317
  — diamond, i. 177
  — eudiometry, i. 383
  — heat, i. 174
  — —— specific, i. 233
  — light, i. 179
  — nomenclature, i. 176, 183
  — oxygen, i. 175
  — salts, i. 174, 178
  — specific heat, i. 233
Laws, general, of chemical changes, i. 19
  of voltaic decomposition, i. 273

Lead, ii. 525, 163
  analysis of its compounds, ii. 412
  —— ores, ii. 412
  purification of gold and silver by, ii. 282
  production of oxygen from oxides of, i. 311
  Goulard's extract of, iii. 169
  and gold, ii. 288
  red, ii. 164
  white, ii. 170
  sugar of, iii. 167
  its acetate, iii. 162, 163, 167, 350
  — —— used as a test, i. 145
  — alloys, ii. 171
  — amylate, iii. 31, 345
  — arseniate, ii. 210, 447, 532
  — benzoate, iii. 104, 106, 350
  — bigummate, iii. 345
  — binamylate, iii. 31, 345
  — borate, ii. 171
  — carbonate, ii. 170, 527
  — —— analyzed, ii. 414
  — chlorate, ii. 166, 526
  — chloride, ii. 165, 526
  — chromate, ii. 222, 223, 535
  — —— used as a colour, ii. 224
  — —— analyzed, ii. 451
  — citrate, iii. 96, 349
  — combustion, ii. 163
  — detection in waters, ii. 501
  — deutoxide, ii. 164, 526
  — expansion by heat, i. 224
  — ferrocyanate, ii. 171
  — gallate, iii. 100
  — gummate, iii. 19, 345
  — hydrosulphuret, ii. 169, 526
  — hyposulphite, ii. 168
  — iodate, ii. 166, 526
  — iodide, ii. 166, 526
  — laccate, iii. 66
  — laccates, iii. 66
  — malate, iii. 98
  — molybdate, ii. 220, 534
Lead, its molybdate, analyses of, ii. 450
  — moroxylate, iii. 107
  — muriate, ii. 165, 526
  — native analyzed, ii. 414
  — natural states, ii. 163
  — nitrates, ii. 166, 526
  — —— used as a test, i. 150
  — nitrites, ii. 167
  — nitrophosphate, ii. 170
  — ores, ii. 163, 412
  — —— assay of, ii. 415
  — —— analysis of, ii. 412
  — oxalate, iii. 88, 91, 348
  — oxides, i. 221; ii. 164, 348, 526
  — peroxide, ii. 164, 526
  — phosphate, ii. 169, 527
  — —— analyzed, ii. 413
  — phosphite, ii. 169, 527
  — phosphuret, ii. 169, 527
  — preparation, ii. 163, 167
  — properties, ii. 163
  — protoxide, ii. 164, 526
  — saccharate, iii. 28, 345
  — salts, table of, ii. 526
  — subnitrate, ii. 166, 526
  — subphosphate, ii. 170
  — subacetate, iii. 168
  — —— used as a test, iii. 169
  — succinate, iii. 68, 346
  — sulphate, ii. 168, 526
  — —— analysis of, ii. 412
  — sulphite, ii. 168, 526
  — sulphovinate, iii. 154
  — sulphuret, ii. 167, 526
  — —— analysis of, ii. 412
  — superacetate, iii. 168
  — superphosphate, ii. 170
  — tannate, iii. 45, 345
  — tartrate, iii. 79, 84, 343
  — —— with potassa, iii. 84, 347
  — tests, i. 150; ii. 171, 348, 501, 526
Leaf, gold, ii. 283
  silver, ii. 267
Leamington waters, ii. 512

Leaves of plants, their functions, i. 105; iii. 4, 6
Leaves of plants, iii. 116
Leather, nature of, iii. 206
curried, iii. 206
tanned, iii. 206
tawed, iii. 206
Lehman, his geological views, iii. 247
Leibnitz's theory of the earth, iii. 236
Lemery, i. 45, 54
on the Arbor Dianæ, ii. 274
Lemons, acid of, iii. 93
Lentiles, iii. 119
Lepidolite, analysis of, ii. 317
Leslie on refrigeration, i. 122, 247
specific heat, i. 233
the radiation of cold, i. 96
— —— heat, i. 298
Leslie's photometer, i. 300
differential thermometer, i. 231
Leucine, iii. 207
Leucite, analysis of, ii. 314, 369
Ley, iii. 57
Leyden phial, i. 259
experiments with, i. 260
polar arrangement of, i. 261
Lias limestone, iii. 295
Libavius, fuming liquor of, ii. 142
Liber of trees, iii. 3
Lichen Islandicus, iii. 125
Lichens, iii. 125
Life supported by oxygen gas, i. 316; iii. 225
Ligaments, iii. 207
Light, i. 286
its absorption, i. 287
— analysis, i. 292
— chemical effects, i. 180, 300, 341
— composition, i. 292
— decomposition, i. 292
— double refraction, i. 288
— effects on crystallization, i. 196
— —— vegetation, i. 179
— —— salts of silver, i. 301
— elementary rays, i. 292
Light, its evolution by electricity, i. 2 272
— —— friction, i. 305
— —— heat, i. 308
— —— percussion, i. 305
— extraordinary refraction, i. 29
— polarization, i. 290
— prismatic colours, i. 292
— properties, i. 287
— reflection, i. 286, 288
— refraction, i. 287
— sources, i. 286, 303
— velocity, i. 286
electrical, i. 258, 272
phosphorescent, i. 304
solar, i. 292, 341
voltaic, i. 272
of flames, i. 306
a ray of, i. 286
production of magnetism by, i. 3
instrument to measure, i. 300
value of from different sources, 441
Scheele on, i. 164
Light hydrocarbonate, i. 438
Lightning, i. 280
conductors, i. 280
Lignin, iii. 42
Limbourg i. 79
Lime, ii. 60, 510
used as a manure, i. 116
analysis of compounds of, ii. 370
crystallized, ii. 61
Dorking, ii. 325
slaked, ii. 61
—— produces heat, i. 241
oil of, ii. 62
water, ii. 61
test for carbonic acid, ii. 70
its acetate, i. 196; iii. 165, 350
— analysis, ii. 60
— appearance before the blowpip ii. 340
— arseniate, ii. 208, 523

Lime, its arseniate, analyzed, ii. 448
— arsenite, ii. 205
— base, ii. 60
— benzoate, iii. 105, 350
— biphosphate, ii. 69, 512
— borate, ii. 72, 512
— camphorate, iii. 63
— carbonate, i. 198, 429; ii. 60, 70, 493, 511
— —— analyzed, ii. 371
— —— native, ii. 70
— —— phosphorescent, i. 304
— chlorate, ii. 63, 510
— chloride, iii. 63
— citrate, iii. 94, 349
— chromate, ii. 223, 534
— composition, ii. 60, 510
— fluate, ii. 73, 511
— hydrate, ii. 61, 510
— hydriodate, ii. 64, 511
— hydrosulphuret, ii. 65
— hydrophosphuret, ii. 68
— hypophosphite, ii. 68
— hyposulphite, ii. 65, 511
— iodate, ii. 64
— kinate, iii. 108
— meconiate, iii. 71
— moroxylate, iii. 107
— muriate, ii. 62, 510
— —— in mineral waters, ii. 499
— —— used as a test, i. 144
— natural state, ii. 60
— nitrate, ii. 64, 511
— number, ii. 373
— oxalate, iii. 89, 201, 348
— oxyodate, ii. 511
— oxymuriate, ii. 63, 510
— —— used in bleaching, ii. 63
— phosphate, ii. 69, 372, 511; iii. 200
— —— in urine, iii. 193
— phosphite, ii. 69
— phosphuret, i. 411; ii. 68, 511
— preparation, ii. 61
Lime, its properties, ii. 61
— purity ascertained, ii. 370
— quadriphosphate, ii. 70
— salts, table of, ii. 510
— separation from magnesia, ii. 103, 494
— solution in water, ii. 62
— —— carbonic acid, i. 153; ii. 70; iii. 311
— subphosphate, ii. 70
— succinate, iii. 67, 345
— sulphate, i. 194; ii. 66, 511; iii. 290
— —— native, ii. 67
— —— analysis of, ii. 371
— sulphite, ii. 66, 511
— sulphuret, ii. 65
— supercarbonate, ii. 70
— tartrate, iii. 82, 347
— —— with potassa, iii. 82, 347
— tests, i. 143; ii. 72, 340, 491, 511
— tungstate, ii. 225, 228, 535
— —— analyzed, ii. 453
Limestone, ii. 71
argillaceous, iii. 295
bituminous, ii. 72
curvatures of, iii. 285
granular, ii. 71
lias, iii. 295
magnesian, iii. 266
—— analysis of, ii. 371; iii. 266
mountain, iii. 284
—— localities of, iii. 286
—— aspect of, iii. 286
—— chasms in, iii. 286
—— curved, iii. 285
position of, iii. 284
secondary, ii. 71; iii. 284
strata, curved, iii. 285
transition, iii. 284
white and blue lias, iii. 295
Lime-water, ii. 62
a test for carbonic acid, i. 143
Linseed oil, expansion of, by heat, i. 225

Liquefaction, i. 119
Black on, i. 239
produces cold, i. 239
Liquid blue, iii. 48
muriatic acid, i. 343
Liquids, i. 285
compounds of solids and heat, i. 243
expansion of, by heat, i. 224
their conducting power for heat, i. 237
evolve heat on solidifying, i. 241
absorb heat on vaporizing, i. 243
specific heat of, i. 233
produced from gases, i. 214
their specific gravity ascertained, ii. 7
Liquor ammoniæ, i. 362
—— acetatis, iii. 164
—— subcarbonatis, i. 433
arsenicalis, ii. 205
calcis, ii. 62
plumbi subacetatis, iii. 168
potassæ subcarbonatis, ii. 43
silicum, ii. 298
Liquorice, iii. 111
List of electrical conductors, i. 254
the metals, ii. 1
Litharge, ii. 164
Lithia, ii. 57, 509
minerals containing it, ii. 57
prepared, ii. 57
its analysis, ii. 57
— appearance before the blow-pipe, ii. 341
— carbonate, ii. 59, 510
— chlorate, ii. 510
— muriate, ii. 58
— nitrate, ii. 58, 510
— phosphate, ii, 59, 510
— properties, ii. 58
— salts, table of, ii. 509
— sulphate, ii. 59, 510
— tests, ii. 341, 509
Lithic acid, iii. 192
Lithium, ii. 57, 509
its chloride, ii. 58, 509
— combinations analyzed, ii. 508
— iodide, ii. 58
— oxide, ii. 57, 509
— salts, ii. 509
— sulphuret, ii. 58
Litmus, iii. 125
used as a test, i. 142; iii. 125
Liver of antimony, ii. 178
sulphur, ii. 39
—— volatile, i. 400
Loaf-sugar, iii. 25
Lobster-shell, iii. 214
Logometric scale of Dr. Wollaston, i. 222
Logwood, iii. 115
Lowitz on the properties of charcoal, i. 418
production of cold by solution of potash, ii. 32
Lucullite, ii. 72; iii. 288
Lully, Raymond, i. 13
Luminous bodies, phænomena of, i. 303
fish, i. 305
ray, i. 286
spiral tubes, i. 259
Luna cornea, ii. 270
Lunar caustic, ii. 273
Lupin seeds, iii. 120
Lutes, ii. 324
vitrifiable, i. 403
Lycopodium, iii. 121
Lymph, iii. 188
nature of, iii. 188

MACBRIDE on fixed air, i. 116
Mac Culloch, Dr., on granite tors, iii. 272
Machine, electrical, i. 255
Macquer on Prussian blue, i. 170
Macquer's neutral arsenical salt, ii. 207
Madder, iii. 110
Magendie on emetin, iii. 42
ipecacuanha, iii. 109

Magistery of bismuth, ii. 185
Magnesia, ii. 95, 515
Black on, i. 115
Hoffman on, i. 115
calcined, ii. 95
caustic, ii. 95
mild, ii. 100
native, ii. 95
its acetate, iii. 165, 350
— ammonio-nitrate, ii. 97, 516
— —— phosphate, ii. 100, 516; iii. 194
— —— sulphate, ii. 99, 516
— appearance before the blowpipe, ii. 340
— arseniate, ii. 208, 532
— arsenite, ii. 205
— base, ii. 95
— benzoate, iii. 105
— bicarbonate, ii. 101, 517
— biphosphate, ii. 100, 516
— borate, ii. 101, 517
— carbonate, ii. 100, 495, 517
— —— analyzed, ii. 378
— chlorate, ii. 97, 515
— citrate, iii. 95, 349
— composition, ii. 95
— compounds analyzed, ii. 376
— hydrate, ii. 515
— hydriodate, ii. 97, 515
— hypophosphate, ii. 99
— hyposulphate, ii. 97, 516
— muriate, ii. 96, 497, 515
— nitrate, ii. 97, 516
— oxalate, iii. 89, 348
— phosphate, ii. 99, 516; iii. 195
— —— with ammonia, ii. 100; iii. 194
— phosphuret, ii. 99
— preparation, ii. 95
— properties, ii. 95
— salts, table of, ii. 515
— salts, tests of, ii. 101, 515
— separation from lime, ii. 100, 103, 378, 494
Magnesia, its sources, ii. 95
— succinate, iii. 67, 346
— sulphate, ii. 98, 516
— —— analyzed, ii. 376
— —— with potassa, ii. 99, 516
— sulphite, ii. 97, 516
— sulphuret, ii. 97
— tartrate, iii. 82, 347
— tests, ii. 102, 340, 491, 515
— tungstate, ii. 228
Magnesiæ carbonas, ii. 100
Magnesian fossils, ii. 102
—— analyzed, ii. 378
limestone, ii. 102; iii. 266
—— analyzed, ii. 371; iii. 266
Magnesite, ii. 101
Magnesium, ii. 95
its amalgam, ii. 95
— compounds analyzed, ii. 376
— chloride, ii. 96, 515
— iodide, ii. 97
— oxide, ii. 95, 515
— salts, table of, ii. 515
Magnetic iron ore, ii. 114
—— analyzed, ii. 383
pyrites, ii. 118
—— analyzed, ii. 384
Magnetism produced by electricity, i. 278
light, i. 302
its application as a test, ii. 336
Malachite, ii. 159, 411
Malate of lead, iii. 98
Malic acid, iii. 97, 349
its preparation, iii. 97
— properties, iii. 98
— composition, iii. 98
the same with the sorbic acid, iii. 97
Malleable metals, list of the, ii. 8
Malt, iii. 31
its composition, iii. 32
process of making, iii. 31
Malt, spirit, iii. 151
Maltha, iii. 75
Malting, iii. 31

Malting, converts starch into sugar, iii. 32
Malus on polarization of light, i. 291
Manganesane (chloride of manganese), ii. 106
Manganesate of potassa, ii. 106
Manganese, ii. 3, 104, 517
  Scheele on, i. 106
  tinges glass, ii. 110
  its acetate, iii. 165, 350
  — arseniate, ii. 208, 532
  — benzoate, iii. 105
  — carbonate, ii. 109, 517
  — chlorate, ii. 106
  — chloride, ii. 106, 517
  — citrate, iii. 96, 349
  — compound with potash, ii. 106
  — compounds analyzed, ii. 381
  — —— table of, ii. 517
  — deuto-sulphate, ii. 108
  — deutoxide, ii. 105, 517
  — hydrated oxide, ii. 105
  — hyposulphite, ii. 108, 517
  — muriates, ii. 106
  — nitrates, ii. 107, 517
  — ores analyzed, ii. 381
  — oxalate, iii. 348
  — —— with potassa, iii. 90, 348
  — oxides, ii. 104, 345, 382, 517
  — —— their composition, ii. 105, 517
  — —— used in glass-making, ii. 299
  — peroxide, ii. 105, 517
  — phosphate, ii. 109, 517
  — phosphite, ii. 109, 517
  — phosphuret, ii. 109, 517
  — preparation, ii. 104
  — presence in mineral waters, ii. 500
  — properties, ii. 104
  — protoxide, ii. 105, 517
  — salts, ii. 106, 109, 517
  — separation from iron, ii. 104, 381, 382
  — sources, ii. 104
  — succinate, iii. 67, 342
  — sulphate, ii. 108, 517
Manganese, its sulphuret, ii. 108
  — tartrate, iii. 82, 347
  — tests, i. 142; ii. 109, 345, 517
  — tungstate, ii. 218, 535
  — uses, ii. 109
Manganesic acid, ii. 106
Manheim gold, ii. 161
Manna, iii. 29
  metallorum, ii. 245
Manure, iii. 9
  lime recommended for, i. 116; iii. 9
Maple sugar, iii. 27
Marble, iii. 265
  localities of in Britain, iii. 265
  primitive, iii. 265
  black, iii. 288
  secondary, iii. 284
  statuary, iii. 265
  is phosphorescent, i. 304
  its geological position, iii. 266
Marbre di Bergamo, ii. 68
Marcet on calculi, iii. 202
  carburet of sulphur, i. 452
  chloride of silver, ii. 271
  serum, iii. 177
Margarate of potassa, iii. 210
Margaritic acid, iii. 210
Margraaf, i. 148
Marking ink, ii. 275
Marl, red, iii. 288
Marls, ii. 72
  analysis of, iii. 322
Marly clay, ii. 320
Marmor metallicum (native sulphate of baryta,) ii. 85
Mars, saffron of, ii. 112
Martial, Ethiops, ii. 112
  regulus, ii. 182
Mascagnine, i. 397
Mass, its influence on chemical affinity, i. 81, 216
Massicott, ii. 164
Mastic, iii. 65
Matches, phosphoric, i. 403

Matrix, iii. 305
Matrass, ii. 243
Matter, imponderable, i. 285
  radiant, i. 285
  —— heat, i. 293
  —— light, i. 286
  powers and properties of, i. 191
  its forms, i. 285
  — —— how modified, i. 192
  — —— or states, modified by heat, i. 238
Mayer, on the conducting power of woods for heat, i. 235
Mayow, i. 64, 97, 131
  on chemical affinity, i. 73
  — hydrogen, i. 71
  — metallic salts, i. 73
  — nature of salts, i. 73
  — respiration, i. 69
Measures, English, i. 457
  —— reduced to French, i. 459
  French, i. 459
  —— reduced to English, i. 461
Mechanical division influences chemical affinity, i. 216
Meconiate of ammonia, iii. 71
  lime, iii. 72
  potassa, iii. 71
  soda, iii. 71
Meconic acid, iii. 70, 346
Medicated waters, artificial, i. 147
Medicine, improved by chemistry, i. 39
Medullin, iii. 43
Melanite, ii. 314
Melasses, iii. 21
Mellilite, iii. 77
Mellitic acid, iii. 77
Melting, points of metals, ii. 11
Membranes, iii. 207
Menachanite, ii. 196
  analyzed, ii. 431
Menilite, ii. 307
Menispermic acid, (from menispermum cocculus,)
Mephitic air, i. 175
Merat-Guillot on lobster-shell, iii. 214
Mercurial horn ore, ii. 247
  trough, i. 128, 320
Mercurius dulcis, ii. 245
  vitæ, ii. 177
Mercurio-pneumatic apparatus, i. 320
Mercury, ii. 242, 537
  native, ii. 242
  calcined, ii. 243
  fulminating, iii. 157
  assay of its ores, ii. 459
  nitric oxide of, ii. 254
  forms amalgams with metals, ii. 260
  action of oxygen on, ii. 243
  —— chlorine on, ii. 244
  —— sulphur on, ii. 254
  its acetate, iii. 169, 350
  — alloys, ii. 260
  — amalgam with ammonia, ii. 261
  — —— copper, ii. 260
  — —— gold, ii. 291
  — —— potassium, ii. 260
  — —— silver, ii. 281
  — —— sodium, ii. 260
  — —— zinc, ii. 260
  — arseniates, ii. 259, 539
  — benzoate, iii. 106
  — bi-chloride, ii. 247, 537
  — bi-persulphate, ii. 257
  — bi-sulphuret, ii. 255, 538
  — black oxide, ii. 243
  — black sulphuret, ii. 254
  — borate, ii. 259, 539
  — capacity for heat, i. 232
  — carbonates, ii. 258, 539
  — chlorate, ii. 537
  — chlorides, ii. 244, 537
  — chromate, ii. 222, 259
  — citrate, iii. 96, 349
  — congelation, ii. 242
  — cyanuret, i. 446; ii. 258, 539
  — compounds analyzed, ii. 458
  — expansion by heat, i. 225
  — hydriodate, ii. 537

Mercury, its iodate, ii. 252
— iodide, ii. 252, 537
— molybdate, ii. 220, 259
— muriate, ii. 247
— —— used as a test, i. 150
— —— with ammonia, ii. 251
— murio-sulphate, ii. 459
— nitrate, ii. 252, 538
— —— used as a test, i. 144
— nitroxide, ii. 254
— oxalate, iii. 92, 348
— oxides, ii. 242, 349, 537
— oxymuriate, ii. 247
— —— used as a test, i. 150
— oxynitrate, ii. 253
— oxyphosphate, ii. 258
— perarseniate, ii. 539
— percarbonate, ii. 258, 539
— perborate, ii. 539
— perchlorate, ii. 250
— perchloride, ii. 247
— periodide, ii. 537
— pernitrate, ii. 252, 538
— peroxide, ii. 243, 537
— peracetate, iii. 170
— perphosphate, ii. 258, 539
— persulphate, ii. 257, 538
— phosphate, ii. 258, 539
— phosphuret, ii. 258
— preparation, ii. 242
— properties, ii. 242
— protacetate, iii. 170
— proto-arseniate, ii. 539
— protocarbonate, ii. 258, 539
— protoborate, ii. 539
— protochlorate, ii. 251
— protochloride, ii. 244
— protonitrate, ii. 252, 538
— protophosphate, ii. 539
— protosulphate, ii. 256, 538
— protoxide, ii. 243, 537
— purification, ii. 242
— red oxide, ii. 243
— — sulphuret, ii. 255

Mercury, its sources, ii. 242
— submuriate, ii. 244
— subnitrate, ii. 253
— suboxynitrate, ii. 253
— subperacetate, iii. 170
— subpernitrate, ii. 253, 538
— subpersulphate, ii. 257, 538
— subsulphate, ii. 257
— sulphate, ii. 256, 538
— —— and ammonia, ii. 258
— sulphuret, ii. 254, 459, 538
— superperacetate, iii. 170
— supernitrate, ii. 253
— supersulphate, ii. 257
— tartrate, iii. 86, 347
— tests, ii. 260, 349, 537
— volatilization, ii. 242
— white precipitate, ii. 251
Mesotype, ii. 313
Metallic acids, ii. 13
—— action of blowpipe on, ii. 309
alloys, ii. 24
ammoniurets, ii. 17
arseniates, ii. 207, 532
arsenites, ii. 206
borates, ii. 22
borurets, ii. 22
carbonates, ii. 22
carburets, ii. 22
chlorates, ii. 14
chlorides, ii. 13
chromates, ii. 223, 534
colours for glass, ii. 304
hydrates, ii. 15
hydriodates, ii. 14
hydrogurets, ii. 15
hydrurets, ii. 15
hyposulphates, ii. 18
hyposulphites, ii. 17
iodates, ii. 15
iodides, ii. 14
lustre, ii. 5
nitrates, ii. 16
ores, ii. 4

Metallic oxides, ii. 12
    native, ii. 4
    decomposed by chlorine, ii. 13
    action of the blowpipe on, ii. 339
    soluble in acids, i. 178
    phosphates, ii. 21
    phosphurets, ii. 21
    salts, native, ii. 5
    sulphates, ii. 18
    sulphites, ii. 18
    sulphurets, ii. 17
    —— native, ii. 5
    veins, iii. 304
    —— dates of, iii. 307
    —— formation of, iii. 306
    —— accidents of, iii. 305
    —— indications of, iii. 307
Metalliferous rocks, iii. 305
    districts, iii. 308
Metallization of ammonia, ii. 261
Metals, enumeration of, ii. 1
    anciently known, ii. 3
    symbols of the seven ancient, ii. 3
    are electromotors, i. 268
    contact of, produce electricity, i. 186, 268
    not soluble in acids, i. 178
    classed, ii. 25
    table of, ii. 505
    table of brittle, ii. 9
    —— ductile, ii. 8
    —— hard, ii. 10
    —— malleable, ii. 8
    —— their specific gravity, ii. 5, 505
    —— —— tenacity, ii. 9
    —— precipitates by ferro-prussiate of potassa, ii. 126
    —— according to their attraction for oxygen, ii. 26
    action of acids on, i. 178
    —— ammonia on, ii. 16
    —— boron on, ii. 22
    —— carbon on, ii. 22
    —— chloric acid on, ii. 14
Metals, action of chlorine on, ii. 13
    —— heat on, ii. 11
    —— hydrogen on, ii. 15
    —— iodic acid on, ii. 15
    —— iodine on, ii. 14
    —— muriatic acid on, ii. 14
    —— nitric acid on, ii. 16
    —— oxygen on, ii. 11
    —— phosphorus on, ii. 21
    —— sulphur on, ii. 17
    —— sulphuretted hydrogen on, ii. 19
    —— sulphuric acid on, ii. 18
    —— water on, ii. 15
    their alloys, ii. 22
    —— ammoniurets, ii. 17
    —— borates, ii. 22
    —— borurets, ii. 22
    —— carbonates, ii. 22
    —— carburets, ii. 22
    —— chlorates, ii. 14
    —— chlorides, ii. 13
    —— coloured precipitates, ii. 20, 126; iii. 101
    —— combustion, i. 273; ii. 12
    —— —— by electricity, i. 273; ii. 12
    —— compounds, table of, ii. 505
    —— crystallization, i. 194
    —— ductility, ii. 8
    —— equivalent numbers, table of, ii. 505
    —— expansion by heat, i. 224
    —— fusibility, ii. 11
    —— fusion by voltaic electricity, i. 273
    —— general properties, ii. 1
    —— history, ii. 3
    —— hydrates, ii. 15
    —— hydrosulphurets, ii. 19
    —— hydrurets, ii. 15
    —— hyposulphates, ii. 18
    —— hyposulphites, ii. 17
    —— iodates, ii. 15
    —— iodides, ii. 14
    —— malleability, ii. 8

Metals, their native states, ii. 4
—— nitrates, ii. 16
—— opacity, ii. 5
—— oxides, ii. 12
—— oxydation, ii. 12
—— phosphates, ii. 21
—— phosphurets, ii. 21
—— power of conducting heat, i. 235 ; ii. 5
—— —— electricity, i. 254, 277 ; ii. 5
—— properties, ii. 1
—— relative expansibility, i. 221
—— specific gravity, tables of, ii. 5, 505
—— sulphates, ii. 16
—— sulphites, ii. 18
—— sulphurets, ii. 17
—— symbols, ii. 8
—— tenacity, ii. 9
—— tests, i. 143, 150 ; ii. 20, 126 ; iii. 100
—— transmutation, i. 6
—— volatility, ii. 11
Meteoric iron, ii. 238
stones, ii. 110, 236
their supposed sources, ii. 239
Meteorolites, ii. 236
Metre, i. 459
Mica, characters of, iii. 253
uses of, iii. 253
uranitic, ii. 193
slate, iii. 254
composition of, iii. 253
Micaceous iron ore, ii. 114
Microcosmic salt, ii. 53 ; iii. 194
Miemite, ii. 102
Milk, i. 169 ; iii. 182
properties of, iii. 182
vinous fermentation of, iii. 185
acid of, iii. 184
sugar of, i. 169 ; iii. 184
of sulphur, i. 387
Mindererus's spirit, iii. 164
Mineral adipocere, iii. 76
Mineral asphaltum, iii. 75
caoutchouc, iii. 76
cameleon, ii. 106
pitch, iii. 75
tar, iii. 75
veins, iii. 304
waters, i. 116, 141 ; ii. 487, 502
—— arrangement of, ii. 487
—— analysis of, i. 146 ; ii. 484,
—— carbonated, ii. 502
—— chalybeate, ii. 502
—— carbonic acid in, i. 427
—— examination of, ii. 487
—— saline, ii. 502
—— sulphureous, ii. 502
—— substances contained in 489
—— table of, ii. 502
—— tests required for their ex nation, ii. 485
yellow, ii. 165
Minerals, aluminous, ii. 312
magnesian, ii. 102
siliceous, ii. 306
silico-aluminous, ii. 313
analysis of, ii. 358
tested by the blow-pipe, ii. 337
Miners' safety-lamp, i. 307, 443; iii.
Mines of salt, iii. 290
fire-damp of, i. 442
Minium, ii. 164
Mint, purification of spoiled air b 132
Minus electricity, i. 250
Mispickel, ii. 215
Mixture, freezing, i. 2
of gases, i. 329
Moffat waters, ii. 502
Moirée métallique, ii. 127
Molasses, iii. 21
Molybdate of ammonia, ii. 219, 534
of lead, ii. 220, 534
—— —— analyzed, ii. 450

Molybdate of mercury, ii. 220, 259
of nickel, ii. 220
— potassa, ii. 219, 534
— silver, ii. 220, 541
— soda, ii. 220, 534
Molybdenum, ii. 4, 218, 533
its acids, ii. 218, 533
— ores, ii. 218
— —— analyzed, ii. 450
— oxides, ii. 218, 533
— preparation, ii. 218, 533
— properties, ii. 218
— sulphuret, ii. 220, 533
— ——— analyzed, ii. 450
— tests, ii. 342
Molybdic acid, i. 168 ; ii. 218, 342, 533
its properties, ii. 219
— salts, ii. 219, 534
Molybdous acid, ii. 218
Mont Blanc, iii. 268
Moonstone, iii. 253
Mordant, iii. 47
Moroxylate of lead, iii. 107
lime, iii. 107
Moroxylic acid, iii. 107
Morphia, iii. 69, 346
— carbonate, iii. 70
— nitrate, iii. 70
— preparation, iii. 69
— properties, iii. 70
— sources, iii. 69
— sulphate, iii. 69
is poisonous, iii. 69
Morrichini on the magnetizing power of the prismatic spectrum, i. 302
Mortar, ii. 324
Morveau on acetate of bismuth, iii. 169
on nomenclature, i. 183
Mosaic gold, ii. 144
Mother-of-pearl shells, iii. 213
Motion of light, i. 286
applied to explain the phænomena of heat, i. 297
Motors of electricity, i. 268
Mountain azure, ii. 160
barometer, i. 371
cork, ii. 318
green, ii. 159
limestone, iii. 284
—— its position, iii. 284
—— curved, iii. 285
—— caverns of, iii. 286
—— aspect of, iii. 285, 286
wood, ii. 318
Mountains, primitive, heights of several, iii. 268, 276
measured by the barometer, i. 370
Mucilage, iii. 19
Mucic, or mucous acid, iii. 19, 184
Mucus, iii. 189
Mulberry calculi, iii. 201
Muller on tellurium, ii. 4
Multiplier, electrical, i. 266
Muriacite, ii. 67
Muriate of ammonia, i. 47, 366, 466
— ——— and platinum, ii. 293
— ——— mercury, ii. 251
— baryta, ii. 82
— —— used as a test, i. 143
— —— oxygenized (chlorate) ii. 83
— bismuth, ii. 185
— cerium, ii. 198
— cinchonine, iii. 113
— cobalt, ii. 189
— copper, ii. 151
— gold, ii. 284
— —— and potassa, ii. 285
— iron, ii. 116
— lead, ii. 165, 526
— lime, ii. 62
— —— in mineral waters, ii. 499
— —— used as a test, i. 144
— —— oxygenized, ii. 63
— lithia, ii. 58
— magnesia, ii. 96, 497
— manganese, ii. 106
— mercury, ii. 247
— —— used as a test, i. 150

Muriate of nickel, ii. 233
of platinum, ii. 293
— —— and ammonia, ii. 293
— potassa, ii. 32
— —— and gold, ii. 285
— —— oxygenized, ii. 33
— silver, ii. 270
— soda, ii. 48, 361 ; iii. 194, 290
— —— oxygenized, ii. 50
— strontia, ii. 90
— strychnia, iii. 73
— tellurium, ii. 200
— tin, ii. 142
— titanium, ii. 197
— zinc, ii. 134
Muriates, tests of, i. 144 ; ii. 490
Muriatic acid, i. 341, 465
prepared by Basil Valentine, i. 30
—— Glauber, i. 47, 49
history of, i. 51
its sources, i. 342
procured, i. 49, 342 ; ii. 40
its properties, i. 343
dephlogisticated, i. 318
oxygenized, i. 167, 318
its solution, i. 343
specific gravity of, i. 344
strength, i. 344
—— ascertained, ii. 357
tests, i. 144
Muriatic acid gas discovered by Priestley, i. 135, 342, ii. 51
action of potassium on, i. 342
its absorption by charcoal, i. 419
— analysis, i. 342
— attraction for water, i. 342
— composition, i. 220, 342
— decomposition, i. 342
— elements, i. 342
— preparation, i. 342
— properties, i. 135, 342
— refraction, i. 288
— solution, i. 342
ether, iii. 159
Muriatic ether, its properties, iii. 159
—— its composition, iii. 159
—— refraction of, i. 288
Murio-sulphate of mercury analyzed, ii. 459
Murray on conducting power of fluids, i. 237
analysis of sea-water, ii. 96
Muschenbroeck on cold, i. 94
Muscle, substance of, iii. 207
component parts of, iii. 207
converted into leucine, iii. 207
Mushet on carburets of iron, ii. 130
Musçovado sugar, iii. 21
Mushrooms, iii. 126
peculiar substance from, iii. 126
Musical sounds produced by flame, i. 329
Mustard, iii. 121
Myrica cerifera, wax from the, iii. 53
Myricin, iii. 54
Myrtle wax, iii. 54

NAILS, iii. 207
Naphtha, iii. 75
native, iii. 75
Narcotic principles, iii. 69
Native antimony, ii. 172
arsenic, ii. 203
copper, ii. 149
gold, ii. 283
green vitriol, ii. 120
iridium, ii. 263
iron, ii. 110, 238
magnesia, ii. 95
mercury, ii. 242
metals, ii. 4
nickel, ii. 232
osmium, ii. 263
palladium, ii. 265
platinum, ii. 292
Prussian blue, ii. 121
sal ammoniac, i. 367
silver, ii. 266
sulphur, i. 387
sulphuric acid, i. 396

Native tellurium analyzed ii. 435
white arsenic, ii. 205
Natrolite, analysis of, ii. 315
Natron (native carbonate of soda) ii. 55
Natural electrical phenomena, i. 279
Needle ore of Siberia analyzed, ii. 421
Negative electricity, i. 250, 261
state of supporters of combustion, i. 274
Nephritic stone, ii. 316
Nerves, pulp of, iii. 212
Neutral salts, i. 222
Neutralization, i. 221
New red sand-stone, iii. 288
Newman's mercurial trough, i. 320
blowpipe, i. 330
Newton, i. 75
on chemical affinity, i. 75
— graduation of thermometers, i. 89
— radiation, i. 285, 297
Nicholas Flammel, i. 13
Nicholson's electrical doubler, i. 266
Nickel, ii. 3, 232, 535
its acetate, iii. 169
— alloy with iron, ii. 241
— —— occurs in meteoric stones, ii. 236
— —— gold, ii. 289
— alloys, ii. 236
— ammonio-nitrate, ii. 234
— —— sulphate, ii. 234, 536
— ammoniuret, ii. 233
— arseniate, ii. 236
— benzoate, iii. 106
— borate, ii. 235, 537
— carbonate, ii. 235, 536
— chloride, ii. 233, 536
— citrate, iii. 96, 349
— ferrocyanate, ii. 235
— hydrate, ii. 232, 535
— hydrosulphuret, ii. 235
— iodide, ii. 233, 536
— molybdate, ii. 220
— muriate, ii. 233
Nickel, its nitrate, ii. 233, 536
its oxalate, iii. 92, 348
— oxides, ii. 232, 347, 535
— ores analyzed, ii. 455
— peroxide, ii. 233
— phosphate, ii. 235, 536
— phosphuret, ii. 235, 536
— preparation, ii. 232
— properties, ii. 232
— protoxide, ii. 232
— sources, ii. 232
— sulphate, ii. 232, 234, 536
— —— analyzed, ii. 457
— —— with potassa, ii. 234, 536
— —— —— iron, ii. 235, 536
— sulphuret, ii. 234, 536
— tartrate, iii. 86, 347
— tests, ii. 236, 347, 535
and cobalt separated, ii. 425, 457
Nicotin, iii. 40
Nightshade, iii. 116
Nigrine, ii. 196
Nikil album, ii. 134
Nitrate of ammonia, i. 367, 466
— —— decomposition of by heat, i. 368
— antimony, ii. 177
— baryta, ii. 83, 513
— bismuth, ii. 185, 528
— cadmium, ii. 408, 523
— cerium, ii. 198
— cinchonine, iii. 113
— cobalt, ii. 190
— copper, ii. 153, 524
— gold, ii. 285, 542
— iron, ii. 117, 519
— lead, ii. 166, 526
— —— used as a test, i. 150
— lime, ii. 64, 511
— lithia, ii. 58, 510
— magnesia, ii. 97, 516
— —— and ammonia, ii. 97
— manganese, ii. 107, 517
— mercury, ii. 252, 538

Nitrate of mercury, used as a test, i. 144
of morphia, iii. 70
— nickel, ii. 233, 536
— —— and ammonia, ii. 234
— potassa, ii. 36, 351, 506
— —— sources of, ii. 36
— —— composition of, ii. 37, 506
— —— used in gunpowder, ii. 38
— silver, ii. 273, 540
— —— use of, as a test, i. 144, 150
— soda, ii. 50, 508
— strontia, ii. 91, 511
— strychnia, iii. 73
— tin, ii. 144, 522
— titanium, ii. 197
— uranium, ii. 194
— urea, iii. 195
— zinc, ii. 135, 520
Nitrates, metallic, ii. 16
in mineral waters, ii. 501
Nitre, ii. 36
crude, ii. 36
purified, ii. 37, 352
fused, ii. 37
cubical, ii. 50
its sources, ii. 36
— decomposition, ii. 37
— composition, ii. 37
— uses, ii. 38
sweet spirit of, iii. 156
oxygen obtained from, ii. 37
—— by Priestley, i. 130
proportion of, in gunpowder, ii. 38
beds, ii. 36
Nitric acid, i. 177, 352, 465
prepared by Basil Valentine, i. 30, 31, 32
tests for its purity, i. 354
table of strength of, i. 356
latent heat in its vapour, i. 245
a test for sulphur, i. 142
diagram of its production, ii. 41
its action on metals, ii. 16
— analysis, i. 356
Nitric acid, its composition, i. 33, 355, 465
its decomposition, i. 33, 356
— elements, i. 355
— expansion by heat, i. 225
— history, i. 31
— nature discovered by Cavendish, i. 33, 156, 352, 357
— preparation, i. 31, 352; ii. 41
— properties, i. 355
— purification, i. 354
— solutions, i. 356
— —— strength of, i. 356
— specific gravity, i. 355
— synthesis, i. 357
Nitric ether, iii. 155
obtained, iii. 156
properties of, iii. 156
its composition, iii. 157
Nitric oxide, i. 177, 349, 465
Priestley on, i. 131
its action on oxygen, i. 351
— analysis, i. 350
— application to eudiometry, i. 131, 383
— composition, i. 350
— decomposition, i. 350
— elements, i. 350
— eudiometrical use, i. 382
— formation, i. 349
— preparation, i. 349
— properties, i. 349
Nitrite of lead, ii. 167
of potassa, ii. 37
— silver, ii. 275
Nitrogen, i. 346, 465; iii. 173
discovered by Rutherford, i. 138, 346
described by Mayow, i. 70
its absorption by charcoal, i. 419
— carburet, i. 446, 469
— chloride, i. 357, 465
— compounds with carbon, i. 446
— —— chlorine, i. 357
— —— iodine, i. 360
— —— hydrogen, i. 361, 466

Nitrogen, its compounds with oxygen, i. 347, 465
its deutoxide, i. 349, 465
— existence in mineral waters, ii. 489
— —— animal substances, iii. 172
— gaseous oxide, i. 347
— iodide, i. 360, 466
— preparation, i. 346
— properties, i. 346
— proportion in the air, i. 384
— protoxide, i. 347
— refractive power, i. 288
— specific gravity, i. 346
— weight, i. 346
Nitro-leucic acid, iii. 207
Nitro-muriate of gold, ii. 284
of platinum, ii. 293
Nitro-muriatic acid, i. 357
saccharine acid, iii. 205
sulphuric acid, ii. 278
Nitro-phosphate of lead, ii. 170
Nitro-tungstate of potassa, ii. 227
Nitrous acid, i. 177, 351, 465
gas procured, i. 351
its composition, i. 351, 465
— elements, i. 351, 465
— properties, i. 351
— solution, i. 352
— synthesis, i. 351
— weight, i. 351
Nitrous air, Cavendish on, i. 157
etherized gas, iii. 155
gas, i. 349
its composition, i. 350
— eudiometrical use, i. 382
oxide, i. 177, 347, 465
—— discovered by Priestley, i. 131
—— obtained, i. 347
—— rationale of its production, i. 368
—— absorbed by charcoal, i. 419
—— its properties, i. 347
—— — analysis, i. 349
Nitrous oxide, its composition, i. 349
—— — decomposition, i. 348
—— — effects on respiration, i. 347
turpeth, ii. 253
Nitrum fixum, ii. 37
flammans, i. 369
Noble serpentine, iii. 263
Nomenclature, French, i. 183
of acids, i. 310
— chemistry, i. 173, 176, 183, 309
— chlorides, i. 309
— combustible compounds, i 311
— oxides, i. 309
Non-conductors, i. 254
electrics, i. 254
Nooth's apparatus, i. 427
Norton, Thomas, i. 24
Nucleus, effect of, on crystallization, i. 195
Numbers, equivalent, of elementary bodies and their compounds, i. 464; ii. 505
Nutritive principles of vegetables, iii. 36
table of, iii. 127

OATS, their composition, iii. 37
Oberkampf on sulphuret of gold, ii. 287
Objects of chemistry, i. 191
Obsidian, ii. 308
Occidental topaz, ii. 313
Octoëdrite, ii. 195
Oersted on electric magnetism, i. 273
Oil, iii. 55
Dippel's animal, iii. 173
gas, i. 441
of almonds, iii. 119
— amber, iii. 67
— bricks, iii. 56
— lime, ii. 62
— linseed, expansion of by heat. i. 225
— olives, iii. 55
— tartar per deliquium, ii. 48

Oil, of turpentine, iii. 64
— —— expansion of, i. 225
— —— latent heat in vapour of, i. 245
— vitriol, i. 389
— —— glacial, i. 35, 396
— —— its history, i. 33
— wine, iii. 153
Oils, animal, iii. 208
drying, iii. 56
fixed, iii. 55, 208
—— how obtained, iii. 55
—— their sources, iii. 55
—— —— varieties, iii. 55
—— —— properties, iii. 55
—— —— combustion, iii. 209
—— —— distillation, iii. 56, 208
—— —— composition, iii. 58
—— —— conversion into wax, iii. 209
—— —— densities, iii. 55
—— action of acids on, iii. 209
—— form soaps with alcalis, iii. 57, 209
—— —— plasters with oxide of lead, iii. 58
philosophers', iii. 56
vegetable, iii. 55
volatile or essential, iii. 58
—— their sources, iii. 59
—— —— preparation, iii. 58
—— —— properties, iii. 60
—— —— varieties, iii. 59
—— —— adulterations detected, iii. 60
Ointments, iii. 54
Old red sandstone, iii. 288
Olefiant gas, procured, i. 435
forms a fluid with chlorine, i. 437
its properties, i. 435
— analysis, i. 436
— absorption by charcoal, i. 419
— composition, i. 436, 469
Oleic acid, iii. 210
Oleum æthereum, iii. 153
Olibanum, iii. 66
Oliva on the subpernitrate of mercury, ii. 253
Olive oil, refraction of, i. 288
its adulteration detected, iii. 55
Olivin, ii. 381
Onion, iii. 124
Onyx, ii. 307
Oolite, ii. 72; iii. 295
Opacity, what, i. 287
of the metals, ii. 5
Opal, varieties of, ii. 307
common, ii. 307
noble, ii. 307
Opium, iii. 69
morphia from, iii. 69
meconic acid from, iii. 70
Ores, metallic, ii. 4
general analysis of, i. 148; ii. 381
Organic remains, iii. 278, 295, 297, 311
Oriental topaz, ii. 312
Origin of coal, iii. 293
Orpiment, ii. 214
used as a dye, ii. 214
Osmazome, iii. 207
Osmium, ii. 4, 262
its ores, ii. 262
— preparation, ii. 262
— properties, ii. 262
— oxides, ii. 262
— tests, ii. 262
Oxalate of ammonia, iii. 88, 348
of antimony, iii. 348
— alumina, iii. 92
— baryta, iii. 89, 348
— bismuth, iii. 92, 348
— cobalt, iii. 92, 348
— copper, iii. 90, 348
— —— and soda, iii. 91, 348
— —— — ammonia, iii. 90, 348
— —— — potassa, iii. 91, 348
— iron, iii. 90, 348
— lead, iii. 88, 91, 348

Oxalate of lime, iii. 89, 201, 348
of magnesia, iii. 89, 348
— manganese, iii. 348
— —— and potassa, iii. 90
— mercury, iii. 92, 348
— nickel, iii. 92, 348
— potassa, iii. 88, 348
— silver, iii. 92, 348
— soda, iii. 89, 348
— strontia, iii. 89, 348
— tin, iii. 90, 348
— zinc, iii. 90, 348
Oxalates, iii. 88, 348
Oxalic acid, iii. 86, 348
how obtained, iii. 87
its properties, iii. 87
— composition, iii. 17, 88
native, iii. 86
used as a test, i. 143
poisonous, iii. 92
Ox-bile, iii. 186
Oxidability of alloys, ii. 25
Oxidation, ii. 11
Oxide, cystic, ii. 202
carbonic, i. 420, 469
nitric, i. 349, 465
nitrous, i. 347, 465
xanthic, iii. 202
of antimony, ii. 173, 527
— —— hydrosulphuretted, ii. 179
— arsenic, ii. 203, 531
— barium, ii. 77, 512
— bismuth, ii. 184, 528
— —— analyzed, ii. 423
— cadmium, ii. 402
— carbon, i. 420, 469
— cerium, ii. 198, 530
— chlorine, i. 320, 341, 464
— chromium, ii. 221, 534
— cobalt, ii. 188, 529
— columbium, ii. 230, 535
— copper, ii. 149, 404, 523
— gold, ii. 284, 542
— hydrogen, i. 339
Oxide of iron, ii. 111, 518
— —— native, ii. 111
— lead, i. 221; ii. 164, 526
— —— hydrosulphuretted, ii. 19
— magnesium, ii. 95, 515
— manganese, ii. 104, 382, 517
— mercury, ii. 242, 537
— molybdenum, ii. 218, 533
— nickel, ii. 232, 535
— nitrogen, i. 347, 465
— osmium, ii. 262
— phosphorus, i. 403, 467
— platinum, ii. 292
— potassium, ii. 30, 505
— selenium, ii. 202
— silicium, ii. 297
— silver, ii. 268, 540
— sodium, ii. 47, 507
— strontium, ii. 89, 514
— tellurium, ii. 199, 530
— tin, ii. 140, 521
— —— analyzed, ii. 396
— titanium, ii. 196
— tungsten, ii. 225, 535
— uranium, ii. 193, 530
— yttrium, ii. 330
— zinc, ii. 134, 520
— —— analyzed, ii. 390
— zirconium, ii. 326
Oxides, ii. 12
their nature, ii. 12
—— production, ii. 12
metallic, ii. 12
—— definite, i. 221; ii. 13
—— native, ii. 4
hydrosulphuretted, ii. 19, 145, 179
sulphuretted, ii. 17
many soluble in water, ii. 13
action of the blowpipe on, ii. 339
increase of weight in, explained by Rey, i. 60
terminology of, ii. 13
Oxidizement, ii. 12
Oxidule (or protoxide),

- *Oxiodic acid*, i. 324, 341, 464
- *Oxiodine*, i. 324, 464
- *Oxiodate of barium*, ii. 82, 513
  - calcium, ii. 511
  - potassium, ii. 35, 505
  - sodium, ii. 50, 508
- *Oxychlorate of potassa*, ii. 35, 505
  - soda, ii. 508
  - mercury, ii. 251
- *Oxychlorates*, ii. 14
- *Oxychloric acid*, i. 322, 464
- *Oxygen*, i. 130, 176, 309, 311, 464
  - its supposed necessity to combustion, i. 67, 317
  - laws respecting its union with bodies, ii. 13
  - its action on metals, ii. 11
  - — compound with boron, i. 453
  - — —— carbon, i. 420
  - — —— chlorine, i. 320
  - — —— hydrogen, i. 330
  - — —— iodine, i. 324
  - — —— nitrogen, i. 347
  - — —— metals, ii. 11
  - — —— phosphorus, i. 403
  - — —— sulphur, i. 387
  - — —— water, i. 339
- *Oxygen gas* discovered by Priestley, i. 129
  - —— Scheele, i. 163
  - Lavoisier on, i. 175, 317
  - supports combustion, i. 316
  - —— animal life, i. 316; iii. 225
  - forms water with hydrogen, i. 330
  - its absorption by charcoal, i. 419
  - — —— burning bodies, i. 317
  - — disappearance during combustion, i. 317
  - — existence in mineral waters, ii. 489, 492
  - — preparation, i. 129, 311
  - — properties, i. 130, 316
  - — proportion in the atmosphere, i. 381
- *Oxygen gas*, its purity tested, i. 381
  - — refractive power, i. 298
  - — sources, i. 311
  - — weight, i. 316, 464
- *Oxygenated water*, i. 339; ii. 78
  - prepared, ii. 79
  - its properties, ii. 81
- *Oxyhydrogen blowpipe*, i. 330
- *Oxyiodine*, i. 324, 464
- *Oxymuriate of antimony*, ii. 177
  - of iron, ii. 118, 519
  - — lime, ii. 63
  - — mercury, ii. 248
  - — potassa, ii. 33
  - — soda, ii. 50
  - — tin, ii. 143, 522
- *Oxymuriates*, i. 322
- *Oxymuriatic acid*, i. 167, 318
- *Oxynitrate of iron*, ii. 118, 519
  - mercury, ii. 252, 538
- *Oxyphosphate of iron*, ii. 121, 520
- *Oxysulphate of iron*, ii. 120, 519
  - mercury, ii. 257, 538
- *Oxywater*, ii. 78
- *Oysanite*, ii. 195

- *PAINT*, brown, Hatchett's, ii. 160
  - green, Scheele's, ii. 206
- *Palladium*, ii. 4, 265
  - native, ii. 265
  - obtained, ii. 265
  - properties of, ii. 265
  - its preparations, ii. 266
  - — tests, ii. 266
- *Panacea Holsatica*, ii. 41
- *Panchymagogum minerale*, ii. 245
- *Pancreatic juice*, iii. 189
- *Paracelsus*, i. 39, 97
  - on zinc, ii. 3
- *Parenchyma of plants*, iii. 3
- *Paris plaster*, ii. 66
  - Pharmacopœia, i. 54
- *Paris, Dr.*, on the smell of arsenic, ii. [illegible]

Paris, Dr., on elaterium, iii. 123
Parker on purification of coal gas, i. 439
Parkes on citric acid, iii. 98
on sulphuric acid, i. 391
— manufacture of tin-plate, ii. 127
Parsnip, composition of, iii. 37
Parts of plants, iii. 108
Pascal, on the air's pressure, i. 370
Patent yellow, ii. 165
Peach blossom cobalt ore, ii. 210
Pearl-ash, ii. 43
its sources, ii. 44
— preparation, ii. 44
the quantity of potassa in ascertained, ii. 44, 354
Pearl white, ii. 185
Pearls, iii. 214
Pearly feldspar, iii. 253
Pearson on laccic acid, iii. 65
potato, iii. 124
Pease, composition of, iii. 37
Peat, iii. 77
Pechblende, ii. 193, 428
analysis of, ii. 428
Pelletier on aurate of potassa, ii. 285
— brucine, iii. 73
— cinchona, iii. 112
— emetin, iii. 42
— iodide of gold, ii. 284
— ipecacuanha, iii. 109
— muriate of lime and carbonic acid, ii. 63
— verditer, ii. 159
— sulphate of morphia, iii. 70
— strychnine, iii. 72
Pellicle in crystallization, i. 193
Pendulum, seconds, length of, i. 458
Pepper, iii. 121
Pepys on the combustion of the diamond, i. 425
— composition of teeth, iii. 215
— respiration, iii. 223
— a soda-water pump, i. 427
— eudiometry, i. 382
Pepys on a gas holder, i. 314
Peracetate of iron, iii. 165
of mercury, iii. 170
— tin, iii. 166
Perarseniate of iron, ii. 532
of mercury, ii. 539
Percarbonate of mercury, ii. 258
Perchlorate of mercury, ii. 251
of potassa, ii. 35, 505
— soda, ii. 508
Perchloric acid, i. 322, 341, 464
Perchloride of carbon, i. 433, 469
of copper, ii. 151, 524
— iron, ii. 116, 518
— mercury, ii. 247, 537
— phosphorus, i. 408, 468
— —— and ammonia, i. 409
— tin, ii. 142, 522
Percussion evolves light, i. 305
Perfumed essences, iii. 60
Perhyposulphite of copper, ii. 524
Periodide of mercury, ii. 252
phosphorus, i. 410
Perkins, on the compressibility of water, i. 338
Perlate acid (acidulous phosphate of soda), ii. 153
Permanent white, ii. 86
Permuriate of copper, ii. 151, 524
of iron, ii. 116, 519
— tin, ii. 143, 522
Pernitrate of iron, ii. 118, 519
mercury, ii. 252, 538
—— and ammonia, ii. 253
Pernitrous acid, i. 350
Peroxalate of copper, iii. 90
iron, iii. 90
Peroxide of antimony, ii. 174, 527
of arsenic, ii. 206, 531
— barium, ii. 78, 79
— calcium, ii. 62
— cerium, ii. 198, 530
— chromium, ii. 221, 534
— cobalt, ii. 188, 529

Peroxide of copper, ii. 149, 524
— —— hydrated, ii. 153
— gold, ii. 542
— hydrogen, i. 339 ; ii. 78
— iron, ii. 112, 518
— lead, ii. 164, 526
— manganese, ii. 105, 517
— mercury, ii. 243, 254, 537
— molybdenum, ii. 218, 533
— nickel, ii. 233
— potassium, ii. 31, 505
— silver, ii. 268
— sodium, ii. 47, 507
— tin, ii. 140, 522
— tungsten, ii. 225
— uranium, ii. 530
Perphosphate of iron, ii. 121, 520
mercury, ii. 258, 539
Perspiration, iii. 224
Persuccinate of iron, iii. 68
Persulphate of copper, ii. 525
iron, ii. 120, 519
mercury, ii. 257, 538
Persulphite of copper, ii. 525
Persulphuret of iron, ii. 118, 519
Peruvian bark, iii. 112
Peschier on krameric acid, iii. 108
Petalite, ii. 57, 368
Petit on specific heat, i. 233
radiant heat, i. 229
Petrifying well, ii. 71 ; iii. 311
Petroleum, iii. 75
latent heat in its vapour, i. 245
Petunse, iii. 252
Pewter, ii. 171, 182
Pfaff on chemical affinity, i. 81
Pharmacolite, ii. 447
Pharmacopœia, chemico-medical, of Schrœder, i. 41
Paris, i. 54
Phænomena, luminous, explained, i. 303
of vegetation, iii. 2
of fermentation, iii. 128
Phial, electrical, i. 259
Phial, Leyden, i. 259
Phillips on alum, ii. 310
on carbonate of ammonia, i. 432
— —— copper, ii. 158, 410
— chalybeate waters, ii. 490
— chemical affinity, i. 217
— emetic tartar, iii. 84
— ferro-arsenical sulphuret of copper, ii. 406
— separation of nickel and cobalt, ii. 425, 457
— —— lime and magnesia, ii. 103
— sesqui-carbonate of soda, ii. 55
— sulphuric ether, iii. 148
— sulphuret of copper, ii. 155
— tartrate of potassa, iii. 80
— tartrate of iron and potassa, iii. 83
— —— antimony and potassa, iii. 84
— vinegar, iii. 161
Philosophers' oil, iii. 56
wool, ii. 134
Phlogistic theory of combustion, i. 61
Phlogisticated air, i. 138
Phlogiston, i. 66, 317
Phosgene gas, i. 421
Phosphate of ammonia, i. 407, 468 ; iii. 194
—— and magnesia, ii. 100 ; iii. 191
of antimony, ii. 180, 528
— arsenic, ii. 215
— baryta, ii. 87, 513
— cadmium, ii. 523
— cobalt, ii. 191, 529
— copper, ii. 158, 525
— —— analyzed, ii. 409
— iron, ii. 120, 519
— —— analyzed, ii. 387
— lead, ii. 169, 527
— —— analyzed, ii. 413
— lime, ii. 69, 372, 512 ; iii. 200
— —— native, ii. 70
— —— in urine, iii. 193

Phosphate of lime, phosphorescent, i. 301
— lithia, ii. 59, 510
— magnesia, ii. 99, 516; iii. 194
— — and ammonia, ii. 100, 516; iii. 194
— manganese, ii. 109, 518
— mercury, ii. 258, 539
— nickel, ii. 235, 536
— platinum, ii. 544
— potassa, ii. 42, 506
— silver, ii. 278, 541
— soda, ii. 52, 509; iii. 194
— — and ammonia, ii. 53, 509; iii. 194
— — — used as a flux, ii. 337
— strontia, ii. 93, 515
— tin, ii. 145
— zinc, ii. 137, 521
Phosphates, metallic, formed, ii. 21
Phosphatic acid, i. 407
Phosphite of ammonia, i. 407, 468
of baryta, ii. 87, 513
— lead, ii. 169, 527
— lime, ii. 69
— magnesia, ii. 99
— manganese, ii. 109
— potassa, ii. 42, 506
— soda, ii. 52, 509
— strontia, ii. 93
— tin, ii. 145
Phosphorane (protochloride of phosphorus), i. 409
Phosphorescence, i. 303
Phosphori, i. 304
solar, i. 304
Phosphoric acid, i. 404, 468
obtained, i. 405
glacial, i. 406
its properties, i. 406
— composition, i. 406
exists in urine, iii. 192
Phosphoric bottles, i. 403
glass, i. 406
matches, i. 403
Phosphorite, ii. 70
Phosphorous acid, obtained, i. 404
its properties, i. 404
— composition, i. 406, 410, 468
— decomposition, i. 413
Phosphorus, i. 401, 467
described by Kunckel, i. 45, 46
Baldwin's, i. 304; ii. 64
Bolognian, i. 301; ii. 86
Canton's, i. 304
Homberg's, ii. 63
Wilson's, i. 301
contains hydrogen, i. 414
its acids, i. 404, 467
— bi-chloride, i. 408, 468
— — composition of, i. 409
— carburet, i. 452
— chlorides, i. 409, 468
— combination with metals, ii. 21
— combustion, i. 403, 405
— cyanuret, i. 451
— eudiometrical application, i. 383
— glass, i. 406
— hydruret, i. 410
— iodide, i. 410
— oxides, i. 403, 467
— periodide, i. 410
— preparation, i. 401, 405
— properties, i. 403
— solution in ether, iii. 150
— sources, i. 401, 405
— sulphuret, i. 414, 468
Phosphuret of antimony, ii. 180, 528
of arsenic, ii. 215
— barium, ii. 87, 513
— bismuth, ii. 186
— calcium, ii. 69, 511
— carbon, i. 452
— cobalt, ii. 191, 529
— copper, ii. 158, 525
— gold, ii. 287, 543
— hydrogen, i. 410, 468
— iron, ii. 120, 519
— lead, ii. 169, 527

Potassa, its hyposulphite, ii. 40, 506
— iodate, ii. 35, 505
— margarate, iii. 210
— meconiate, iii. 71
— molybdate, ii. 219, 584
— muriate, ii. 32
— —— with gold, ii. 285
— nature, ii. 30
— nitrate, ii. 36, 506
— nitrite, ii. 37
— oxalate, iii. 88, 348
— —— with copper, iii. 91, 348
— oxychlorate, ii. 35, 505
— oxymuriate, ii. 33
— perchlorate, ii. 35
— phosphate, ii. 42, 506
— phosphite, ii. 42, 506
— preparation, ii. 31
— properties, ii. 32
— prussiate, ii. 124
— —— used as a test, i. 142
— quadroxalate, iii. 88
— salts, ii. 46
— solution, ii. 39
— —— in alcohol, iii. 145
— sources, ii. 44
— subcarbonate, i. 221 ; ii. 43
— subphosphate, ii. 42, 506
— succinate, iii. 67, 345
— sulphate, ii. 40, 506
— —— with alumina, ii. 309
— —— —— magnesia, ii. 99
— —— —— nickel, ii. 234
— sulphite, ii. 40, 506
— sulphuret, ii. 39
— superoxalate, iii. 89
— superphosphate, ii. 42
— supersulphate, ii. 40
— supertartrate, iii. 80, 346
— synthesis, ii. 30
— tartrate, iii. 79, 346
— —— with ammonia, iii. 81, 346
— —— —— antimony, iii. 84, 347
— —— —— copper, iii. 83
Potassa, its tartrate with iron, iii. 83,
— —— with lime, iii. 82, 347
— —— —— lead, iii. 84, 347
— —— —— soda, iii. 81, 346
— —— —— tin, iii. 83, 347
— tellurate, ii. 201
— tests, ii. 46, 351, 505
— triple prussiate, ii. 124
— tungstate, ii. 227
Potassæ acetas, iii. 164
carbonas, ii. 45
subcarbonas, ii. 43
sulphas, ii. 40
sulphuretum, ii. 39
supersulphas, ii. 40
tartras, iii. 80
Potassium, ii. 4, 28, 505
its action on ammonia, ii. 261
— —— carbonic acid, i. 420
— —— carbonic oxide, i. 421
— —— chlorine, ii. 32
— —— hydrogen, ii. 36
— —— iodine, ii. 35
— —— muriatic acid, i. 342; i
32
— —— oxygen, ii. 30
— —— water, ii. 30
— amalgam, ii. 260
— chloride, ii. 32, 505
— compounds analyzed, ii. 351
— —— table of, ii. 505
— cyanuret, ii. 46
— hydruret, ii. 36, 505
— iodide, ii. 35, 505
— oxides, ii. 30, 505
— peroxide, ii. 31, 505
— phosphuret, ii. 42, 506
— preparation, ii. 28
— properties, ii. 30
— protoxide (potassa), ii. 30, 505
— salts, ii. 505
— sulphuret, ii. 39, 506
Potassiuretted hydrogen gas, ii. 36
Potato, iii. 124

Potato, quantity of starch in, iii. 37
starch, iii. 34
Potential cautery (caustic potassa), ii. 31
Potmetal, ii. 171
Potter's clay, ii. 320
Pottery, ii. 320
Pouges waters, ii. 502
Powder, ii. 38
James's, ii. 180
antimonial, ii. 180
of Algarotti, ii. 177
Powdered tin, ii. 140
Powers of matter, i. 191
Prase, ii. 307
Precipitate, red, ii. 243
per se, ii. 243
Precipitated sulphur, i. 387
Precipitates, colours of, ii. 20, 126; iii. 101
Prehnite, ii. 315
Pressure of the air affects boiling points, i. 241
Price, Dr., i. 25
Priestley, i. 101, 127
nitric acid decomposed by, i. 33
his discovery of muriatic acid gas, i. 51, 135
— —— ammoniacal gas, i. 136
— —— sulphurous acid gas, i. 136
— pneumatic trough, i. 128
— mercurio-pneumatic trough, i. 128
on air, i. 128
— dephlogisticated air, i. 129
— eudiometry, i. 131, 137, 383
— fixed air, i. 129, 141
— nitrous air or oxide, i. 131
— oxygen gas, i. 129
— purification of air, i. 132
— the atmosphere, i. 137
— vegetation, i. 132
Primitive rocks, iii. 242, 248, 251, 267
—— their characters, iii. 267
marble, ii. 71; iii. 265
mountains, height of, iii. 268, 276
Primitive forms of crystals, i. 205
Prince Rupert's drops, ii. 302
metal, ii. 161
Printers' ink, iii. 57
type-metal, ii. 182
Printing on calico, iii. 52
Prismatic rays, i. 292
spectrum, i. 292
Products of vegetable analysis, iii. 11
fermentation, iii. 128
Proof spirit, iii. 144
Properties of matter, i. 191
change of by chemical action, i. 215
Proportions, definite, i. 220, 340
Protacetate of mercury, iii. 170
of iron, iii. 165
— tin, iii. 166
Protarseniate of iron, ii. 532
of mercury, ii. 539
Protiodide of mercury, ii. 252
of phosphorus, i. 410
Protocarbonate of mercury, ii. 258
Protochlorate of mercury, ii. 251
Protochloride of carbon, i. 434, 469
of copper, ii. 150, 521
— iron, ii. 115, 518
— mercury, ii. 244, 537
— tin, ii. 141, 522
Protomuriate of copper, ii. 150
of iron, ii. 116, 518
— tin, ii. 142, 522
Protonitrate of iron, ii. 118, 519
of mercury, ii. 252, 538
Protophosphate of iron, ii. 121, 519
of mercury, ii. 258, 539
Protosuccinate of iron, iii. 68
Protosulphate of copper, ii. 156
of iron, ii. 119, 519
— mercury, ii. 256, 538
Protosulphuret of iron, ii. 118, 519
of mercury, ii. 254, 538
— copper, ii. 154, 521
— tin, ii. 144, 522
Protoxalate of iron, iii. 90

Protoxide of antimony, ii. 173, 527
of arsenic, ii. 203, 531
— cerium, ii. 198, 530
— chrome, ii. 221, 534
— cobalt, ii. 188, 529
— copper, ii. 149, 523
— iron, ii. 111, 518
— lead, ii. 164, 526
— manganese, ii. 105, 517
— mercury, ii. 243, 537
— molybdenum, ii. 218, 533
— nickel, ii. 232
— nitrogen, i. 347
— potassium, ii. 30, 505
— silver, ii. 269
— sodium, ii. 47, 507
— tin, ii. 140, 521
— uranium, ii. 530
Proust on acetates of mercury, iii. 170
arsenic acid, ii. 206
arsenious acid, ii. 205
chloride of silver, ii. 270
hordein, iii. 34
nitrate of copper, ii. 153
oxides of cobalt, ii. 188
Prout on calculi, iii. 201
nitrate of urea, iii. 195
purpuric acid, iii. 193
respiration, iii. 223
the sap of the vine, iii. 8
urea, iii. 196
uric acid, iii. 192
urine, iii. 195
Proximate analysis, i. 223 ; iii. 17, 172
principles of vegetables, iii. 18
—— animals, iii. 172, 175
Prussian blue, ii. 122
process for making, ii. 123
its nature, ii. 122
— properties, ii. 124
Scheele on, i. 170
native, ii. 121
Prussiate of potassa and iron, ii. 122
—— used as a test, i 142
Prussic acid, i. 170, 449
its preparation, i. 449
— properties, i. 450
gas (cyanogen), i. 446
Puddling, ii. 128
Pulp of nerves, iii. 211
Pulvis antimonialis, ii. 180
Pumice, ii. 308
Purification of coal gas, i. 429
sugar, iii. 21
Purple powder of Cassius, ii. 143, 287
Purpuric acid, iii. 193
Pus, iii. 190
Putrefaction, iii. 173
of animal substances, iii. 174
resisted by charcoal, i. 418
retarded by carbonic acid gas, iii.17
—— exclusion of air, iii. 174
Putty of tin, ii. 141
Pycnite, ii. 313
Pyrites, arsenical, ii. 445
copper, ii. 155
iron, ii. 118 ; iii. 312
—— analyzed, ii. 384
magnetical, ii. 118
tin analyzed, ii. 399
Pyrmont water, ii. 502
Pyroacetic ether or spirit, iii. 164
acid, iii. 164
Pyrolignate of lime, iii. 162
Pyroligneous acid, iii. 162
purified, iii. 162
Pyromucous acid, iii. 20
Pyrophorus, Homberg's, i. 54, 166 ; ii. 310
Pyrophysalite, ii. 313
Pyrotartaric acid, iii. 79
Pyro-uric acid, iii. 193

QUADRANT, electrometer, i. 260
Quadriphosphate of lime, ii. 70
Quadroxalate of potassa, iii. 89
Quantity of electricity, i. 266, 276
Quarries, slate, iii. 281

Quartation, ii. 25
Quartz, ii. 306; iii. 251
mountain masses of, iii. 252
Quercitron bark, iii. 50
Quicklime, ii. 72; iii. 288
Quicksilver, ii. 242 (see *Mercury*)
Quills, their nature, iii. 208
Quinine, iii. 113
its acetate, iii. 113
— salts, iii. 113

RADIANT matter, i. 285
—— heat, i. 164, 293
—— light, i. 179, 286
—— productive of chemical changes i. 165, 180, 300, 341
heat, i. 164, 293, 306
—— solar, i. 293
—— terrestrial, i. 294
—— —— transmission of, through glass, i. 296
Radiation of terrestrial heat, i. 93, 294
heat in vacuo, i. 298
cold, i. 93
theory of, i. 297
Radiators, i. 296
Radical vinegar, iii. 161
Radicle of seeds, iii. 4
Rain water, i. 336
Raw sugar, iii. 21
Ray of light, i. 286
electrical, i. 282
Rays, calorific, i. 301
colorific, i. 301
decomposing, i. 301
luminous, i. 301
prismatic, i. 292
solar, their influence in nature, i. 303
Raymond Lully, i. 13
Reagents used by Bergman, i. 142
in examination of mineral waters, ii. 485
Realgar, ii. 213
Reaumur's thermometer, i. 90, 229
Receiver, i. 323
tubulated, i. 343, 353
quilled, i. 353
for gases, i. 313
Receivers of heat, i. 298
Receptive power of bodies for solar heat affected by colour, i. 296
Red dye, iii. 50
fire, ii. 91
lead, ii. 165
—— oxygen obtained from, by Priestley, i. 129
marl, iii. 288
precipitate, ii. 243
—— oxygen obtained from, by Priestley, i. 129
sandal wood, iii. 115
silver ore, ii. 276
sand of urine, iii. 199
sandstone, iii. 288
—— new, iii. 288
—— aspect of, iii. 289
—— its localities, iii. 280
sulphuret of arsenic, ii. 213
Reduction of copper ores, ii. 155
iron ores, ii. 115
lead ores, ii. 168
silver ores, ii. 268
zinc ores, ii. 138
Refiners' verditer, ii. 159
Refining of sugar, iii. 21
Reflected light, i. 288
Reflection of cold, i. 93
of heat, i. 93, 294
— light, i. 288
Refraction, i. 287
of light, i. 287
— heat, i. 93, 293
double, i. 289
extraordinary, i. 290
ordinary, i. 287
Refractive power, table of, i. 288
—— affected by density, i. 288

Refractive power affected by combustibility, i. 288
Refrangibility of the different rays, i. 292
Refrigeration by evaporation, i. 247
Regenerated sea salt, ii. 33
Regulus of antimony, ii. 172
of bismuth, ii. 184
Remains, organic, iii. 278, 295, 296, 297, 311
in secondary rocks, iii. 278
Rennet, iii. 183
Representative numbers, table of, i. 464; ii. 505; iii. 345
Repulsion, electrical, i. 249
Resin of bile, iii. 186
Resinous electricity, i. 250
Resins, vegetable, iii. 64
Respiration, iii. 217, 222
Mayow on, i. 69, 71
Hales on, i. 102
process of, iii. 222
its uses, iii. 223
produces carbonic acid, i. 429; iii. 222, 223, 225
supported by oxygen, i. 316; iii. 225
purification of air spoiled by, i. 132
of fish, iii. 225
— nitrous oxide, i. 347
Resplendent feldspar, iii. 253
Rete mucosum, iii. 203
Retinasphaltum, iii. 76
Retorts, i. 312
Reverberatory furnace, i. xiii.
Rey, his explanation of calcination, i. 60, 66
Rheumic acid (from green rhubarb)
Rhodium, ii. 4, 264
how procured, ii. 264
its ores, ii. 264
— properties, ii. 264
— alloys, ii. 265
— muriate, ii. 264
Rhubarb, iii. 110
Richter on chemical attraction, i. 83
Richter on acetate of alumina, iii. 171
Ripley, George, i. 15
Ritter on radiant matter, i. 301
River water, i. 336
Robert and Charles, their ascent in a balloon, i. 158
Robiquet on asparagin, iii. 41
liquorice, iii. 111
Rochelle salt, iii. 81
Rock crystal, ii. 306; iii. 251
cork, ii. 318
salt, ii. 49
—— mines of in Cheshire, ii. 49; iii. 290
Rocks, aspects of, iii. 249
their decomposition, iii. 309
floetz, iii. 242
primary, iii. 242, 248, 251
—— their characters, iii. 267
secondary, iii. 242, 240, 275
—— their characters, iii. 277
stratified, iii. 275
theory of their formation, iii. 276
transition, iii. 242, 249, 275
varieties of, iii. 249
volcanic, iii. 243, 314
Roebuck, Dr., on sulphuric acid, i. 390
Roemer on light, i. 286
Roe stone, ii. 72
Roger Bacon, i. 9
Rolling of iron, ii. 128
Roll sulphur, i. 387
Roman vitriol, ii. 156
Romé de Lisle on crystallization, i. 197
Roots of plants, i. 108; iii. 2, 109
Rosacic acid (from urine),
Rose diamonds, i. 415
quartz, ii. 307
Rosin of copper, ii. 150
Rothoff on oxides of cobalt, ii. 188
Rouge, iii. 118
Royal Society, notice of the, i. 52
Academy of Sciences, i. 54
Institution, voltaic battery of, i. 272

Royal Institution, laboratory of the, i. xiii.
Rubelite, ii. 471
Ruby, ii. 312
    balass, ii. 312
    copper ore, ii. 149
    spinelle, ii. 312
    silver ore, ii. 276
Rules for correcting the volumes of gases, i. 375
Rum, iii. 131, 135
Rumford on the conduction of heat, i. 236
    conducting power of fluids, i. 237
Rupert's drops, ii. 302
    metal, ii. 161
Rust (oxide of iron), ii. 111
Rutherford, discovery of nitrogen by, i. 138, 346
Rutilite, ii. 196
Rye, its composition, iii. 37

SACCHARATE of lead, iii. 28, 345
Saccharometer, iii. 128
Saccholactates, iii. 165
Saccholactic acid, iii. 19, 185
Safety lamp, Sir H. Davy's, i. 307, 443; iii. 292
    construction of, i. 444
    principle of, i. 307, 443
Safflower, iii. 118
Saffron, iii. 39
    of antimony, ii. 178
    — mars, ii. 112
Sage on brass, ii. 161
    on sulphuret of bismuth, ii. 425
Sago, iii. 35
Sahlite, ii. 319
Saint Parize waters, ii. 502
Sal alembroth, ii. 251
    ammoniac, i. 47, 366
    —— fixed, ii. 63
    —— secret, i. 47, 396
    catharticus amarus (sulphate of magnesia), ii. 108
Sal de duobus, ii. 40
    diureticus (acetate of potassa), iii. 164
    enixum, ii. 41
    gem (rock salt), ii. 49; iii. 290
    jovis, ii. 143
    martis (green sulphate of iron), ii. 119
    mirabile, i. 47, 49; ii. 51
    perlatum, ii. 53
    polychrest Glaseri (sulphate of potassa), ii. 40, 38
    prunelle, ii. 37
Salifiable bases, i. 178
Saline mineral waters, ii. 502
Saliva, iii. 189
    nature of, iii. 189
Salmon, Dr., i. 14
Salop, iii. 35
Salt, ammoniacal fixed, ii. 63
    —— secret (sulphate of ammonia), i. 396
    arsenical of Macquer (superarseniate of potassa), ii. 207
    bitter, ii. 98
    common, ii. 49; iii. 289
    culinary, ii. 49
    digestive of Sylvius (acetate of potassa), iii. 164
    diuretic (acetate of potassa), iii. 164
    Epsom, ii. 98
    febrifuge of Sylvius (muriate of potassa), ii. 33
    fusible, ii. 53; iii. 194
    Glaser's polychrest, ii. 38
    Glauber's, i. 49; ii. 51
    hair, ii. 98
    marine (muriate of soda), ii. 49
    microcosmic, ii. 53; iii. 194
    petre, ii. 36
    —— its properties, ii. 37
    —— — composition, ii. 37
    —— — uses, ii. 38
    Rochelle, iii. 81
    rock, ii. 49; iii. 289

Salt, sedative, i. 54, 454
spirit of, i. 341
sulphureous (sulphite of potassa), ii. 40
tasteless, ii. 52
of amber (succinic acid), iii. 66
— hartshorn, iii. 173
— lemons (superoxalate of potassa), iii. 89
— Saturn, iii. 167
— Seidlitz, ii. 98
— Seignette, iii. 81
— sorrel, iii. 86
— Sylvius, ii. 33; iii. 164
— tartar, ii. 43
— Venus, ii. 157
— wormwood, ii. 43
Salts, nature of explained by Mayow, i. 73
Lavoisièr on, i. 174, 178
separation of by crystallization, i. 195
neutral, decomposition of, i. 169
metallic, native, ii. 5
nomenclature of, i. 310
Sand, aggregation of into rocks, iii. 311
in urine, white, iii. 193, 199
—— red, iii. 199
Sand-heat, i. xiv. xv.
Sandiver, ii. 301
Sandstone, old red, iii. 288
modern, iii. 311
Sandstones, iii. 296
Santorio, the supposed inventor of the thermometer, i. 86
Sap-green, iii. 123
Sap of plants, iii. 8
motion of, iii. 7
Sapphire, ii. 312
Sapwood, iii. 3
Sardonyx, ii. 307
Sassolin, i. 454
Satin spar, ii. 71
Saturation, i. 221
Saturn, ii. 163
salt of, iii. 167
Saunders wood, iii. 115
Saussure on alcohol, iii. 146
on the water of the atmosphere, i. 384
— — combustion of alcohol, iii. 145
— — conversion of starch into sugar, iii. 33
— ether, iii. 152
— granite boulders, iii. 270
— naphtha, iii. 75
— vegetable substances, iii. 16
his hygrometer, i. 385
Saxon blue, iii. 48
green, iii. 52
Scale of equivalents, i. 222
Scales of fishes, iii. 214
thermometers, i. 230
Scapolite, ii. 316
Scarborough waters, ii. 502
Scarlet dye, iii. 51
use of tin, in, iii. 51
Scheele, i. 138, 156, 162
discovered oxygen, i. 163
his eudiometer, i. 381
— green colour, i. 168; ii. 206
— theory of heat, i. 163, 164
on arsenic acid, i. 168
— arseniate of copper, i. 168
— analysis of the air, i. 163
— calomel, ii. 246
— chemical decomposition, i. 168
— chlorine, i. 318
— dephlogisticated muriatic acid, i. 167, 318
— eudiometry, i. 381
— fluor spar, i. 167
— gallic acid, iii. 98
— lactic acid, iii. 185
— light and heat, i. 164
— malic acid, iii. 97
— manganese, i. 51, 166
— milk and sugar of milk, i. 169

Scheele on muriatic acid, i. 61, 167
    — molybdic acid, i. 168
    — plumbago, i. 168
    — Prussian blue, i. 170
    — radiant matter, i. 301
    — sulphuretted hydrogen, i. 166, 398
    — tungstates, ii. 227
    — vegetable acids, i. 170
Scheele's green, i. 168; ii. 206
    eudiometer, i. 381
Scheelium, ii. 225
Scherer on the sap of the maple, iii. 8
Schiller spar, iii. 264
    composition of, iii. 264
Schorl, ii. 316
Schorlous beryl, ii. 313
Schrœder, his chemico-medical pharmacopæia, i. 41
Scillitin, iii. 125
Scudamore on manganese in mineral waters, ii. 500
Sea fish, when luminous, i. 305
Sea salt, ii. 48
    regenerated, ii. 33
    water, analysis of, ii. 96
Sebacic acid (from fat)
Secondary rocks, iii. 242, 249, 276
    —— character of, iii. 277
    —— height of, iii. 219, 276
    —— formation of, iii. 249, 277
    —— structure of, iii. 249, 278
    —— varieties of, iii. 280
Seconds' pendulum, length of, i. 458
Secret sal ammoniac, i. 47, 396
Secretions, animal, iii. 182
Section of England, geological, iii. 250
Sedative salt, i. 54, 454
Seed lac, iii. 65
Seeds of plants, iii. 4, 118
    —— growth of, i. 109; iii. 5
Seggars, ii. 321
Seguin on eudiometry, i. 383
Seidlitz waters, ii. 502
Seignettes salt, iii. 81
Seleniates, ii. 202, 441
Seleniate of baryta, ii. 441
Selenic acid, ii. 292, 441
Selenite, ii. 67; iii. 290
Selenium, ii. 4, 201, 440
    its properties, ii. 201, 441
    — acid, ii. 441
    — chloride, ii. 441
    — hydruret, ii. 442
    — ores analyzed, ii. 442
    — oxides, ii. 441
    — phosphuret, ii. 442
    — sulphuret, ii. 442
Seleniuretted hydrogen gas, ii. 441
Seltzer water, ii. 502
Senna, iii. 116
Separation of iron and manganese, ii. 104, 381, 382
    of lime and magnesia, ii. 100, 103, 378, 494
    — nickel and cobalt, ii. 425, 457
    — salts by crystallization, i. 196
Serosity, iii. 178
Serpentine, iii. 262
    appearances of, iii. 262
    analysis of, ii. 378, 380
    localities of, in Britain, iii. 262
    noble, iii. 263
Serteurner on morphium, iii. 69
    on œnothionic acid, iii. 153
Serum, iii. 176
    analysis of, iii. 176
    of chyle, iii. 220
Sesqui-carbonate of soda, ii. 55
    phosphate of baryta, ii. 87
Shale, iii. 290
Shear-steel, ii. 129
Shell lac, iii. 65
Shells, iii. 212
    egg, iii. 214
    lobster, iii. 214
    mother-of-pearl, iii. 213
    porcellaneous, iii. 213

Shock, electrical, i. 260
Silex, ii. 297 (See *Silica*)
Silica, its sources, ii. 297
its preparation, ii. 297
— properties, ii. 298
— nature, ii. 297
— native states, ii. 306
— detection in mineral waters, ii. 490
— composition, ii. 297
— solution in potassa, ii. 298
insoluble in most of the acids, ii. 305
when soluble in acids, ii. 298, 469
its hydrate soluble in acids, ii. 298
dissolves in alcalis, ii. 298
forms glass with alcalis, ii. 298
exists in plants, iii. 3
Silicated alcali, ii. 298
fluoric gas, ii. 305
Siliceous earth, ii. 297
—— Scheele's idea of its formation, i. 168
minerals, ii. 306
—— analyzed, ii. 469
Silicium, ii. 297, 544
oxide of, ii. 297
Silico-fluate of ammonia, ii. 306
aluminous minerals, ii. 313
Silk, bleached by sulphurous acid gas, i. 389
Silveira on zirconia, ii. 327, 478
Silver, ii. 266, 540
fulminating, ii. 269 ; iii. 158
glance, ii. 276
horn, ii. 270
native, ii. 266
standard, ii. 280
and steel, ii. 280
— copper, ii. 280
its acetate, iii. 170, 350
— alloys, 280
— amalgam, ii. 281
— ammoniuret, ii. 540
Silver, its arseniate, ii. 279, 541
— arsenite, ii. 279
— assay, ii. 281
— benzoate, iii. 106
— borate, ii. 279, 541
— carbonate, ii. 279, 541
— —— with ammonia, ii. 279
— chlorate, ii. 272, 540
— chloride, ii. 270, 540
— —— composition of, ii. 271
— —— decomposition of, ii. 270
— —— absorbs ammonia, ii. 271
— chromate, ii. 279, 542
— citrate, iii. 96, 349
— combustion, ii. 267
— cupellation, ii. 281
— cyanuret, ii. 279, 540
— hyposulphite, ii. 276
— —— with potassa, ii. 277
— iodate, ii. 273
— iodide, ii. 272, 540
— molybdate, ii. 220, 541
— nitrate, ii. 273, 540
— —— fused, ii. 273
— —— decomposed, ii. 274
— —— used as a test, i. 141, 144, 150
— —— forms marking ink, ii. 275
— nitrite, ii. 275
— ores, ii. 266
— —— reduced, ii. 268
— —— analyzed, ii. 460
— oxalate, iii. 92, 348
— oxides, ii. 268, 540
— phosphate, ii. 278, 541
— phosphuret, ii. 278, 541
— preparation, ii. 267
— properties, ii. 267
— salts, ii. 280
— sulphate, ii. 277, 541
— sulphite, ii. 277, 541
— sulphuret, ii. 276, 541
— tartrate, iii. 86, 347
— tarnish, ii. 267

Silver, its tungstate, ii. 542
— tests, ii. 280, 540
grain of trees, iii. 4
Silvering powder, ii. 281
of silk, ii. 274
Similor, ii. 161
Simple decomposition, i. 217
supporters of combustion, i. 309
acidifiable and inflammable substances, i. 326
Singer's electrometer, i. 252
Single decomposition, i. 217
Sirup, iii. 27
Size, how prepared, iii. 206
its uses, iii. 205
Skeletons of Guadaloupe, iii. 314
Skin, iii. 203
its essential principle, iii. 208
how changed in tanning, iii. 206
Slaked lime, ii. 61
Slate, varieties of, iii. 281
uses of, iii, 280, 281
districts, iii. 282
quarries, iii. 281
clay, iii. 280
appearance of, iii. 282
grauwacke, iii. 281
its composition, iii. 280
Slickensides, ii. 168
Smalt, ii. 192
Smeaton on mortar, ii. 325
Smelting of iron ores, ii. 115
of copper ores, ii. 155
— zinc ores, ii. 138
— lead ores, ii. 168
Smith on urinary calculi, iii. 291
Smithson on calamine, ii. 394
on colouring matter of flowers, iii. 117, 118
— litmus, iii. 126
— sap green, iii. 123
Snow, how crystallized, i. 194
Soap, iii. 57
how made, iii. 57
Soap, its nature, iii. 57
— solution in alcohol, iii. 57
— —— a test, i. 145; iii. 57
hard, iii. 57
soft, iii. 57
transparent, iii. 57
glass, ii. 209
Soapstone, ii. 102; iii. 262, 264
analysis of, iii. 265
Soapy rock, iii. 264
Society, Royal, notice of, i. 52
Soda, ii. 48
pure obtained, ii. 48
distinguished from potassa, ii. 48
native, ii. 55
tartarizata, iii. 81
water, i. 427
of commerce, examination of, ii. 54, 354
its acetate, iii. 162, 164, 350
— alcoholic solution, iii. 145
— ammonio-phosphate, ii. 53, 509
— ammonio-sulphate, ii. 52, 508
— arseniate, ii. 208, 532
— arsenite, ii. 205
— benzoate, iii. 105, 350
— bicarbonate, ii. 54, 363, 509
— biphosphate, ii. 53, 509
— bisulphate, ii. 52, 508
— borate, ii. 56, 509
— camphorate, iii. 63
— carbonates, ii. 53, 362, 499, 509
— —— procured, ii. 53
— —— their purity ascertained, ii. 54, 362
— chlorate, ii. 50, 507
— chloride, ii. 48, 507
— chromate, ii. 223
— citrate, iii. 94, 349
— composition, ii. 47
— decomposition, ii. 47
— hydrate, ii. 48, 507
— hydriodate, ii. 508
— hydrofluate, ii. 75

Soda, its hydrosulphuret, ii. 50
- — hyposulphite, ii. 51, 508
- — iodate, ii. 50, 508
- — iodide, ii. 50, 508
- — meconiate, iii. 71
- — molybdate, ii. 220, 534
- — muriate, ii. 48; iii. 194, 290
- — —— decomposed by litharge, ii. 165
- — nitrate, ii. 50, 508
- — oxalate, iii. 89, 348
- — —— with copper, iii. 91
- — oxychlorate, ii. 508
- — phosphate, ii. 52, 509; iii. 194
- — —— with ammonia, ii. 53, 509; iii. 194
- — phosphite, ii. 52, 509
- — preparation, ii. 48
- — properties, ii. 48
- — salts, table of, ii. 507
- — sesqui-carbonate, ii. 55
- — solution in alcohol, iii. 145
- — sources, ii. 48, 53
- — subborate, ii. 56, 363, 509
- — subcarbonate, ii. 53
- — succinate, iii. 67, 345
- — sulphate, i. 47, 50, 169, 194, 241; ii. 51, 361, 508
- — —— with alumina, ii. 311
- — sulphite, ii. 51, 508
- — sulphuret, ii. 50
- — supertartrate, iii. 81
- — synthesis, ii. 47
- — tartrate, iii. 81, 346
- — —— with potassa, iii. 81, 346
- — tests, ii. 48, 361, 507
- — tungstate, ii. 228

Sodæ carbonas, ii. 54
- subcarbonas, ii. 54, 362
- sulphas, ii. 51

Sodalite, analysis of, ii. 315, 363

Sodane, (chloride of sodium), ii. 48

Sodium, ii. 4, 47, 507
- and potassium, ii. 56

Sodium, its alloys, ii. 56
- its amalgam, ii. 260
- — chloride, ii. 48, 361, 507
- — compounds analyzed, ii. 361
- — iodide, ii. 50, 507
- — oxides, ii. 47, 507
- — phosphuret, ii. 509
- — preparation, ii. 47
- — properties, ii. 47
- — salts, table of, ii. 507
- — sulphuret, ii. 50, 508

Soft water, i. 336
- soap, iii. 67
- solders, ii. 187

Soils, formation of, iii. 312
- cold, iii. 332
- composition of, iii. 327
- cultivation of, iii. 340
- their subsoil, iii. 339
- improvements of, iii. 330
- temperature of, iii. 332
- varieties of, iii. 329
- analysis of, iii. 316
- operation of the, iii. 330
- water of, iii. 334

Solar radiant matter, i. 292
- —— light, i. 292
- —— heat, i. 293
- phosphori, i. 304
- beams, influence of, on vegetation, i. 303

Solders, ii. 187

Solid produced from combining gases, i. 214

Solidification produces expansion, i. 228
- —— heat, i. 241

Solids, i. 285
- expansion of by heat, i. 224
- produce cold on liquefying, i. 239
- specific heat of, i. 232

Solution, i. 214
- generally produces cold, i. 239
- heat, absorbed by, i. 239
- of chlorine i. 319
- — ammonia, i. 361

Solution of muriatic acid, i. 342
Sonorousness of the metals, ii. 10
Sorbic acid, iii. 97
  the same as the malic, iii. 97
Sorrel, salt of, iii. 86
Sounds produced by flames, i. 329
South on acetate of lead, iii. 168
  on distillation of sulphuric acid, i. 395
Sowing of seeds, iii. 6
Spa water, ii. 502
Spar, adamantine, ii. 312
  bitter, ii. 102
  calcareous, ii. 70
  Derbyshire, ii. 73
  fluor, i. 167; ii. 73, 373
  Iceland, i. 289; ii. 70
  ponderous, ii. 85
  satin, ii. 67, 71
Spark, electrical, i. 258
Spathose iron ore, ii. 122
Specific gravity, ii. 6
  how taken, ii. 6
  altered by change of temperature, i. 223, 463; iii. 137
  of alcohol, iii. 136
  — —— diluted, iii. 137
  — alloys, ii. 23
  — ammonia, i. 361
  — atmospheric air, i. 373
  — carbonic acid, i. 422
  — carbonic oxide, i. 420
  — carburetted hydrogen, i. 435
  — chlorine, i. 319
  — elements and their compounds, i. 464
  — ether, iii. 149
  — fluids, ii. 7
  — gases, i. 464
  — hydrogen, i. 327
  — ice, i. 338
  — iodine, i. 324
  — metals, ii. 5, 505
  — mineral waters, ii. 448
Specific gravity of muriatic acid, i. 342
  of nitric acid, i. 356
  — nitric oxide, i. 349
  — nitrogen, i. 346
  — nitrous acid gas, i. 351
  — nitrous oxide, i. 347
  — oils, volatile, iii. 59
  — oxygen, i. 316
  — solids, ii. 6
  — solutions of alcohol, iii. 138
  — —— ammonia, i. 361
  — —— muriatic acid, i. 344
  — —— nitric acid, i. 356
  — —— sulphuric acid, i. 392
  — steam, i. 338
  — sulphur, i. 386
  — sulphuretted hydrogen, i. 398
  — sulphuric acid, i. 392
  — volatile oils, iii. 59
  — water, i. 338
  — —— at different temperatures, i. 462
  — wort, iii. 129
Specific heat, i. 232
  of bodies estimated, i. 233
  formula for ascertaining, i. 232
Spectrum, prismatic, i. 292
  solar heat in, i. 298
  decomposing rays in, i. 301
Specular iron ore analyzed, ii. 383
Speculum metal, ii. 162
Speiss, ii. 232
Spermaceti, iii. 211
  is phosphorescent, i. 304
Sphene, ii. 196
Spherical theory of crystallization, i. 208
Spinelle ruby, ii. 312
  analyzed, ii. 472
Spiral luminous tube, i. 259
Spirit of wine, iii. 131, 135
  of hartshorn, iii. 173
  — mindererus, iii. 164
  — nitre, i. 352
  — salt, i. 47, 343

Spirit proof, iii. 144
  pyroacetic, iii. 164
  thermometer, i. 230
  —— invented by the academicians del Cimento, i. 87
Spirituous liquors, strength of ascertained, iii. 144
  table of strength of, iii. 132
  solution of soap, i. 145; iii. 57
Spiritus ætheris nitrici, iii. 156
  —— sulphurici, iii. 151
Spodumene, analysis of, ii. 57, 315, 368
Spring-water, i. 336
Squills, iii. 125
Stahl's chemical discoveries, i. 64
  elements of matter, i. 66
  theory of combustion, i. 66, 316
Stalactites, ii. 71, iii. 308
  formation of, iii. 308
Standard silver, ii. 280
Stannane, (protochloride of tin) iii. 142
Stannanea, (bi-chloride of tin) ii. 142
Stannic acid, ii. 143
Starch, iii. 17, 29, 118, 345
  how prepared, iii. 30
  its properties, iii. 30
  — hydrate, iii. 30
  — composition, iii. 17, 33
  — iodide, ii. 30
  — tests, iii. 30, 31
  — varieties, iii. 34
  — conversion into sugar by malting, iii. 31
  — —— by sulphuric acid, iii. 32
  a test for iodine, iii. 30
States of matter affected by heat, i. 238
Statuary marble, ii. 71
Staurolite, analysis of, ii. 319
Staurotide, analysis of, ii. 315
Steam, i. 121, 338, 465
  its elasticity, i. 243, 338
  — expansion by heat, i. 225
  — force at different temperatures, i. 243
Steam, its latent heat, i. 121, 244
  its specific gravity, i. 338, 465
  — temperature, i. 243, 338
  heating by, i. 51, 245, 246
  —— introduced by Glauber, i. 51
  engine, i. 123
  boiler for experiments, i. 245
  globe for experiments on pressure, i. 243
Stearin, iii. 55, 209
  its quantity in fats and oils, iii. 209
Steatite, ii. 102; iii. 262, 264
  analysis of, iii. 265
Steel, ii. 129
  its alloy with alumium, ii. 308
  — —— nickel, ii. 241
  — —— rhodium, ii. 265
  — —— silver, ii. 280
  — alloys, ii. 133
  — colours, ii. 132
  — expansibility by heat, i. 224
  — formation, ii. 129
  — temper, ii. 131
  — texture, ii. 131
  — varieties, ii. 129
  cast, ii. 129
  Indian, ii. 130
  —— analyzed, ii. 387
  shear, ii. 129
  tilted, ii. 129
  gilding of, by ether, iii. 150
Stibic acid, ii. 175
Stibious acid, ii. 175
Stibium (antimony) ii. 172
Stick lac, iii. 65
Stilbite, ii. 313
Still, i. 337
Stink stone, ii. 72
Stodart on gilding by ether, iii. 151
  — tempering of steel, ii. 132
  — coating steel with platinum by ether, iii. 151
  and Faraday on alloys of nickel, ii. 241

Stodart and Faraday on carburets of iron, ii. 129
—— steel and platinum, ii. 296
——— silver, ii. 280
Stonehenge, iii. 296
Stones, analyses of, ii. 469
meteoric, ii. 236
Strata, their succession, iii. 249
of England, iii. 250
Stratified rocks, iii. 275
Stream tin, ii. 141
Strength of sulphuric acid, i. 391
of nitric acid, i. 356
— muriatic acid, i. 344
— ammonia, i. 361
— spirituous liquors, iii. 132
Stromeyer on arragonite, ii. 376
on arseniuretted hydrogen, ii. 212
— cadmium, ii. 4
— —— ores, analysis, ii. 402
— meteoric stones, ii. 210
Strontia, ii. 89, 514
distinguished from baryta, ii. 94, 514
tinges flame red, ii. 94 ; iii 145
water, ii. 90
its acetate, iii. 165, 350
appearance before the blow-pipe, ii. 339
— arseniate, ii. 208, 532
— arsenite, ii. 205
— base, ii. 89
— benzoate, iii. 105
— borate, ii. 94, 515
— carbonate, ii. 93, 376, 515
— —— native, ii. 93
— chlorate, ii. 90, 514
— chromate, ii. 223
— citrate, iii. 96, 349
— composition, ii. 89
— hydrate, ii. 89, 514
— hydriodate, ii. 91
— hydrosulphuret, ii. 91
— hypophosphite, ii. 92
Strontia, its hyposulphite, ii. 92, 514
— iodate, ii. 91, 514
— muriate, ii. 90, 514
— nitrate, ii. 91, 514
— oxalate, iii. 89, 348
— phosphate, ii. 93, 515
— phosphite, ii. 93
— preparation, ii. 89
— properties, ii. 89
— salts, table of, ii. 514
— solution, ii. 90
— sources, ii. 93
— succinate, iii. 67, 346
— sulphate, ii. 92, 376, 515
— —— native, ii. 92
— sulphite, ii. 92, 515
— sulphuret, ii. 91, 92, 514
— tartrate, iii. 82, 347
— tests, ii. 94, 339, 514
— tungstate, ii. 228
Strontianite, ii. 93
Strontites (See *Strontia*) ii. 89
Strontium, ii. 89, 376, 514
its chloride, ii. 90, 514
— compounds analyzed, ii. 376
— iodide, ii. 91, 514
— oxide, ii. 89, 514
— phosphuret, ii. 93
— salts, table of, ii. 514
— sulphuret, ii. 91, 514
— tests, ii. 514
Structure of crystals, i. 197
of plants, iii. 2
— the earth's surface, iii. 248
Strychnia, iii. 72, 346
its muriate, iii. 73
— nitrate, iii. 73
— sulphate, iii. 73
Strychnine, iii. 72
Subacetate of lead, iii. 168
—— copper, iii. 167
Subborate of soda, ii. 56
Subcarbonate of ammonia, i. 482
—— magnesia, ii. 100

Subcarbonate of potassa, ii. 43
—— soda, ii. 54
—— —— use of as a flux, ii. 337
Subchloride of copper, ii. 150
—— lead, ii. 165
Suber, iii. 43
Suberic acid, iii. 43
Sublimate, corrosive, ii. 247
—— used as a test, i. 145
mild, ii. 245
Sublimation, i. 194 ; ii. 245
Sublimatum dulce, ii. 245
Sublimed sulphur, i. 386
Submuriate of copper, ii. 152
of mercury, ii. 244
— tin, ii. 143
Subnitrate of copper, ii. 153
of lead, ii. 166
— mercury, ii. 253
— uranium, ii. 194
Subordinate formations, iii. 243
Suboxynitrate of mercury, ii. 253
Suboxysulphate of mercury, ii. 257
Subpercarbonate of copper, ii. 158
Subpermuriate of copper, ii. 151, 524
Subpernitrate of copper, ii. 153
of mercury, ii. 253
Subpersulphate of mercury, ii. 257
Subphosphate of lead, ii. 170
of lime, ii. 70
— potassa, ii. 42, 506
Subsilicated fluoric acid, ii. 305
Subsulphate of antimony, ii. 179
of copper, ii. 157
— mercury, ii. 257
Subsulphuret of bismuth, ii. 186
of mercury, ii. 254
Substantive colours, iii. 47
Succession of strata, iii. 247
Succinate of ammonia, iii. 67, 345
of baryta, iii. 67, 346
— copper, iii. 68, 346
— iron, iii. 68, 346
— lead, iii. 68, 346
Succinate of lime, iii. 67, 345
— magnesia, iii. 67, 346
— manganese, iii. 67, 346
— potassa, iii. 67, 345
— soda, iii. 67, 345
— strontia, iii. 67, 346
— tin, iii. 68, 346
— zinc, iii. 68, 346
Succinic acid, iii. 66, 345
its properties, iii. 67
Sugar, iii. 17, 21, 122, 345
animal, i. 169 ; iii. 184, 197
cane, iii. 21
candy, i. 195 ; iii. 22
crystallized, i. 195
loaf, iii. 25
muscovado, iii. 21
vegetable, iii. 21
raw, iii. 21
of milk, i. 169 ; iii. 184
— lead, iii. 167
— urine, iii. 197
its acid (oxalic), iii. 86
— analysis, iii. 28
— artificial production, iii. 31, 42
— composition, iii. 17, 29
— conversion into gum, iii. 28
— preparation, iii. 21
— properties, iii. 27
— purification, iii. 21
— sources, iii. 21, 27
— varieties, iii. 27
formed from starch, iii. 31
—— woody fibre, iii. 42
Sulphate of alumina and potassa, ii. 309
of alumina and soda, ii. 311
— ammonia, i. 47, 396, 467
— —— and copper, ii. 157
— —— — magnesia, ii. 99
— —— — manganese, ii. 382
— antimony, ii. 178, 528
— arsenic, ii. 215
— atropia, iii. 116
— baryta, ii. 85, 513

Sulphate of baryta analyzed, ii. 374
— —— decomposed, ii. 86
— —— its uses, ii. 85
— bismuth, ii. 186
— cadmium, ii. 403, 523
— cerium, ii. 198
— cinchonine, iii. 113
— cobalt, ii. 190, 529
— —— anhydrous, ii. 190
— copper, i. 47; ii. 156, 525
— —— and ammonia, ii. 157
— —— — potassa, ii. 158
— glucina, ii. 329
— gold, ii. 287
— iron, ii. 119, 519
— —— and nickel, ii. 536
— —— analyzed, ii. 386
— —— its history, i. 34
— lead, ii. 168, 526
— —— analyzed, ii. 412
— lime, i. 194; ii. 66, 511; iii. 290
— —— analyzed, ii. 371
— lithia, ii. 59, 510
— magnesia, ii. 98, 377, 516
— —— analyzed, ii. 376
— —— and ammonia, ii. 99
— —— — potassa, ii. 99, 516
— manganese, ii. 108, 517
— mercury, ii. 256, 538
— —— and ammonia, ii. 268
— morphia, iii. 70
— nickel, ii. 232, 234, 457, 536
— —— and ammonia, ii. 234, 537
— —— — iron, ii. 235, 538
— —— — potassa, ii. 234, 536
— platinum, ii. 294; iii. 204
— potassa, ii. 40, 506
— —— and alumina, ii. 309
— —— — ammonia, ii. 42
— —— — copper, ii. 158
— —— — magnesia, ii. 99, 516
— —— — nickel, ii. 234, 536
— silver, ii. 277, 541
Sulphate of soda, i. 47, 49, 169, 194, 241; ii. 51, 361, 508
— —— and alumina, ii. 311
— —— — ammonia, ii. 52
— strontia, ii. 92, 376, 515
— strychnia, iii. 73
— tin, ii. 145, 522
— titanium, ii. 197
— uranium, ii. 194
— zinc, ii. 136, 521
Sulphates, metallic, ii. 18
in mineral waters, ii. 498
tests of, ii. 490
Sulphite of ammonia, i. 389, 467
of baryta, ii. 84, 513
— copper, ii. 156, 524
— lead, ii. 168, 526
— lime, ii. 66, 511
— magnesia, ii. 97, 516
— potassa, ii. 40, 506
— —— and copper, ii. 156
— silver, ii. 277
— soda, ii. 51, 508
— strontia, ii. 92, 515
— tin, ii. 145
— zinc, ii. 136, 521
Sulphites, metallic, ii. 18
Sulphovinate of baryta, iii. 154
— lead, iii. 154
Sulphovinous acid, iii. 154
Sulphur, i. 386, 466
alcohol of, i. 451
hydroguretted, i. 401
liver of, ii. 39
milk of, i. 387
native, i. 386, 387
precipitated, i. 387
roll, i. 386
sublimed, i. 386
contains hydrogen, i. 166, 401
its action on metals, ii. 17
— carburet, i. 451
— combination with carbon, i. 451, 470

Sulphur, its combination with chlorine, i. 397, 467
— —— hydrogen, i. 398, 467
— —— iodine, i. 398, 467
— —— metals, ii. 17
— —— oxygen, i. 387, 466
— —— phosphorus, i. 414, 468
— combustion in chlorine, i. 397
— —— oxygen, i. 388
— cyanuret, i. 451
— flowers, i. 386
— phosphuret, i. 414
— preparation, i. 387
— properties, i. 386
— purity ascertained, i. 387
— sources, i. 386
— tests, i. 142
Sulphurane, i. 397
Sulphureous mineral waters, ii. 502
Sulphuret of antimony, ii. 172, 178, 527
of arsenic, ii. 213, 531
— —— and iron analyzed, ii. 446
— barium, ii. 83, 513
— barytes, ii. 83
— bismuth, ii. 186, 528
— —— analyzed, ii. 421
— cadmium, ii. 523
— calcium, ii. 65, 511
— carbon, i. 452, 470
— cobalt, ii. 190, 529
— copper, i. 213 ; ii. 154, 524
— —— native analyzed, ii. 405
— gold, ii. 287, 542
— iron, ii. 118, 519
— —— analyzed, ii. 384
— lead, ii. 167, 526
— —— analyzed, ii. 412
— —— copper and bismuth analyzed, ii. 421
— lime, ii. 65
— lithium, ii. 58
— magnesia, ii. 97
— manganese, ii. 108
— metals, native, ii. 5
Sulphuret of mercury, ii. 242, 254, 458, 538
of molybdenum, ii. 220, 450, 533
— nickel, ii. 234, 536
— phosphorus, i. 414, 468
— platinum, ii. 298
— potassa, ii. 39
— —— its eudiometrical uses, i. 381
— potassium, ii. 39, 506
— selenium, ii. 442
— silver, ii. 276, 541
— soda, ii. 50
— sodium, ii. 50, 508
— strontia, ii. 91
— strontium, ii. 91, 514
— tin, ii. 144, 522
— uranium, ii. 198
— zinc, ii. 136, 521
— —— analyzed, ii. 391, 398
Sulphurets, hydroguretted, ii. 19
metallic, ii. 17
—— native, ii. 5
nomenclature of, i. 311
Sulphuretted hydrogen, i. 166, 398, 467
prepared, i. 398
its properties, i. 398
— analysis, i. 399
— composition, i. 390
— specific gravity, i. 398
— absorption by charcoal, i. 419
— action on metals, ii. 19
— solution, i. 398
— use as a test, i. 398 ; ii. 20
and ammonia, i. 399
tests for, ii. 480
contained in mineral waters, i. 398, 489, 492
Sulphuretted oxide of antimony, ii. 179
sulphite of zinc, ii. 136
Sulphuric acid, i. 389, 467
prepared by Basil Valentine, i. 30, 33
diluted, i. 391
dry, i. 396
fuming, i. 396
glacial, i. 396

Sulphuric acid, hydrated, i. 391
  native, i. 396
  absorbs water from the atmosphere, i. 390
  and water produce heat, i. 390
  its action on metals, ii. 18
  — analysis, i. 394
  — composition, i. 390
  — decomposition, i. 394
  — distillation, i. 395
  — expansion by heat, i. 226
  — formation, i. 329
  — manufacture, i. 389, 392, 396
  — preparation, i. 34, 389, 396
  — properties, i. 390
  — proportion in diluted acid, i. 392
  — purification, i. 395
  — rationale of production, i. 37, 392
  — sources, i. 389
  — strength ascertained, ii. 357
  — tests, i. 143
  — uses, i. 395
  — —— as a test, i. 143
Sulphuric ether, iii. 147
  prepared, iii. 148
  its properties, iii. 149
  — composition, iii. 152
Sulphuric oxide (sulphurous acid) i. 388, 466
Sulphurous acid, i. 388, 466
  discovered by Priestley, i. 136
  its absorption by charcoal, i. 419
  — composition, i. 388
  — decomposition, i. 389
  — elements, i. 388
  — formation, i. 136, 388
  — properties, i. 389
  — solution, i. 388
  — use in bleaching, i. 389
Sunbeams analyzed, i. 292
  contain three kinds of radiant matter, i. 301
Superacetate of lead, iii. 168
Superantimoniate of ammonia, ii. 176
Superoxalate of potassa, iii. 89
Superoxynitrate of mercury, ii. 253
Superoxysulphate of mercury, ii. 257
Super-pernitrate of mercury, ii. 253
Superphosphate of lead, ii. 170
  of potassa, ii. 43
Supersulphate of ammonia, i. 397
  of bismuth, ii. 186
  — mercury, ii. 257
  — potassa, ii. 40
Supersulphuret of iron, ii. 118
Supersulphuretted hydrogen, i. 401
Supertartrate of potassa, iii. 80
  of soda, iii. 81
Supporters of combustion, i. 309
  are negatively electrical, i. 274
  table of, i. 464
Sweet spirit of nitre, iii. 156
Swine stone, ii. 72
Symbols of the seven ancient metals, ii. 3
Syenitic rocks, iii. 261
Syenite, iii. 261
  its aspect, iii. 262
Sylvius febrifuge salt of, iii. 164
  digestive salt of, ii. 33
Sympathetic ink, ii. 186, 189
Synovia, iii. 199
Synthesis, i. 222
Syrup, iii. 25

TABASHEER, iii. 3
Table of the absorption of gases by charcoal, i. 419
  of acidifiable substances and their compounds, i. 464
  — alcohol in fermented liquors, iii. 132
  — —— and water in different proportions, iii. 136
  — alloys, ii. 24
  — antimony compounds, ii. 527
  — atmospheric pressure, i. 371
  — barium compounds, ii. 512

Table of bismuth compounds, ii. 523
— brittle metals, ii. 9
— cadmium compounds, ii. 523
— calcium compounds, ii. 510
— carburets of iron, their composition, ii. 130
— coloured rays in white light, i. 292
— compounds of acidifiable substances, i. 464
— —— metals, ii. 505
— —— supporters of combustion, i. 461
— composition of vegetable substances, iii. 17
— conducting power of woods, i. 235
— copper compounds, ii. 523
— ductile metals, ii. 18
— elaine in fats and oils, iii. 209
— elementary substances and their compounds, i. 464
— —— acidifiable and acidifying, substances and their compounds, i. 464
— electrics, i. 251
— English measures, i. 459
— —— weights, i. 459
— equivalent numbers of vegetable and animal products, iii. 345
— —— of elementary bodies and their compounds, i. 464
— —— — metals and their compounds, ii. 505
— fermented liquors, their strength, iii. 132
— freezing mixtures, i. 240
— French measures, i. 460
— —— weights, i. 461
— gases absorbed by water, i. 340
— hard metals, ii. 10
— increase of weight of charcoal in the air, i. 419
— iron compounds, ii. 518
Table of latent heat of vapour, i. 245
of lead compounds, ii. 526
— lithium compounds, ii. 509
— magnesium compounds, ii. 515
— malleable metals, ii. 8
— manganese compounds, ii. 517
— metals chronologically arranged, ii. 1
— —— classed, ii. 26
— —— and their compounds, ii. 505
— metallic compounds, ii. 505
— metallic precipitates by ferroprussiate of potassa, ii. 126
— —— —— hydrosulphuret of ammonia, ii. 20
— —— —— infusion of galls, iii. 101
— —— —— sulphuretted hydrogen, ii. 20
— mineral waters, ii. 502
— mixtures of alcohol and water, iii. 138
— muriatic acid, strength of solutions, i. 344
— nitric acid, strength of solutions of, i. 356
— nutritive principles of vegetables, iii. 127
— potassium compounds, ii. 505
— quantity of charcoal from woods, i. 418
— —— alcohol in fermented liquors, iii. 132
— —— essential oils from different substances, iii. 61
— refractive powers, i. 288
— representative numbers of elementary bodies and their compounds, i. 464
— sodium compounds, ii. 507
— solid matter in urine, iii. 198
— specific gravity of the metals, ii. 5, 506
— —— volatile oils, iii. 59

Table of the specific gravity of water at different temperatures, i. 462
— —— diluted alcohol, iii. 138
— stearine in fats and oils, iii. 209
— strength of ammonia in solution, i. 361
— —— fermented liquors, iii. 132
— —— muriatic acid, i. 344
— —— nitric acid, i. 356
— —— sulphuric acid, i. 392
— strontium compounds, ii. 514
— supporters of combustion and their compounds, i. 464
— tannin contained in different barks, iii. 45
— tenacity of metals, ii. 9
— thermometric scales, i. 230
— tin compounds, ii. 521
— urinary solid matter, iii. 198
— value of diamonds, i. 416
— value of light from different sources, i. 441
— varieties of potassa, ii. 45
— vegetable substances, their composition, iii. 17, 345
— volatile oils, their specific gravity, iii. 59
— weights of gases, i. 379
— zinc compounds, ii. 520
Tables, chemical of Geoffroy, i. 78, 217
Gilpin's, iii. 138
Tabular view of elements, their compounds, &c., i. 464
Taddei on gluten, iii. 36
guaiacum, iii. 66
Talc, ii. 102 ; iii. 264
composition of, iii. 264
Tallow, iii. 208
Tannate of lead, iii. 45, 345
Tannin, iii. 44, 120, 345
its sources, iii. 44
— tests, iii. 44
obtained, iii. 44
its properties, iii. 44
Tannin from galls, iii. 44
—— catechu, iii. 44
—— bark, iii. 44
artificial, iii. 45, 120
quantity of in different barks, iii. 45
with gelatine, iii. 204
Tanning, i. 116 ; iii. 206
Tanno-gallate of iron, iii. 102
Tantalite, ii. 229
Tantalium, ii. 229
Tapioca, iii. 35
Tar, mineral, iii. 75
of wood, i. 48
Tarnish of silver, ii. 207
Tartar, iii. 80
cream of, iii. 80
crude, iii. 80
emetic, iii. 84
oil of, per deliquium, ii. 43
salt of, iii. 81
soluble, iii. 79
tincture of, iii. 145
vitriolated, ii. 40
Tartaric acid, iii. 78, 346
obtained, iii. 78
its properties, iii. 79
Tartrate of ammonia, iii. 79, 346
of alumina, iii. 86
— antimony, iii. 347
— antimony and potassa, iii. 84, 347
— baryta, iii. 82, 347
— bismuth, iii. 85, 347
— cerium, iii. 86
— cobalt, iii. 85, 347
— copper, iii. 83, 347
— iron, iii. 82, 347
— —— and potassa, iii. 83, 347
— lead, iii. 79, 84, 347
— lime, iii. 82, 347
— magnesia, iii. 82, 347
— manganese, iii. 82, 347
— mercury, iii. 86, 347
— nickel, iii. 86, 347
— potassa, iii. 79, 3

Tartrate of potassa and ammonia, iii. 81, 346
—— antimony, iii. 84
—— copper, iii. 83
—— iron, iii. 83, 347
—— lead, iii. 84, 347
—— lime, iii. 82, 347
—— mercury, iii. 86, 347
—— silver, iii. 86, 347
—— soda, iii. 81, 346
—— tin, iii. 83, 347
— silver, iii. 86, 347
— soda, iii. 81, 346
— strontia, iii. 82, 347
— tin, iii. 83, 347
— uranium, iii. 85
— zinc, iii. 83, 347
Tassaert on arsenical cobalt, ii. 425
Taste produced by voltaic electricity, i. 269
Tasteless ague drop, ii. 205
Tawed leather, iii. 206
Taylor on oil gas illumination, i. 441
Tears, iii. 189
Teeth, iii. 216
enamel of, iii. 215
Tellurate of potassa, ii. 201
Tellurates metallic, ii. 201
Telluretted hydrogen, ii. 200
Tellurium, ii. 4, 199, 530
its chloride, ii. 200, 530
— hydriodate, ii. 200
— hydruret, ii. 200
— iodide, ii. 200
— muriate, ii. 200
— oxide, ii. 199, 345, 530
— preparation, ii. 199
— properties, ii. 199
— tests, ii. 201, 345
is acidifiable, ii. 201
ores of, ii. 199, 434
—— analyzed, ii. 434
black ore of, analyzed, ii. 438
grey ore of, analyzed, ii. 436
yellow ore of, analyzed, ii. 436
Tellurium, native, analyzed, ii. 435
Temperature, i. 248
measured by thermometer, i. 229
influence of on chemical affinity, i. 216
of different boiling points, i. 241
— fusing points of metals, ii. 11
— soils, iii. 332
changes of by solution, i. 239
—— solidification, i. 241
—— evaporation, i. 247
Tempering of steel, ii. 131
Tenacity of metals, ii. 9
Tendons, iii. 207
Tension of electricity, i. 265
Tennant on dolomite, iii. 266
on iridium, ii. 4, 263
— ores of platinum, ii. 468
— osmium, ii. 4, 263
Tennantite, ii. 155
Terra foliata tartari, iii. 164
crystallizata, iii. 164
Terrestrial radiant heat, i. 294
Tests, first described by Boyle, i. 140
used by Bergman, i. 142
examination of mineral waters by, ii. 487
for acids, i. 142, 215
— alkalies, i. 142, 215
— antimony, ii. 527
— arsenic, ii. 216, 531
— baryta, ii. 512
— bismuth, ii. 528
— cadmium, ii. 523
— copper, ii. 523
— examination of mineral waters ii. 485
— iron, ii. 518
— lead, ii. 171, 525
— lime, ii. 510
— lithia, ii. 509
— magnesia, ii. 515
— manganese, ii. 517
— metals, i. 150 ; ii. 20, 126 ; iii 101

Tests, for platinum, ii. 293
— potassa compounds, ii. 505
— silver, ii. 280, 540
— soda compounds, ii. 507
— strontia, ii. 514
— tin, ii. 521
— urinary calculi, iii. 200
— zinc, ii. 520
Texture, effect of on the conducting power of bodies, i. 236
Thallite, ii. 317
Thenard on albumen, iii. 179
on alloys of arsenic, ii. 215
— analysis of vegetable substances, iii. 12
— antimonic acid, ii. 176
— arseniate of lead, ii. 447
— arsenious acid, ii. 205
— arseniuretted hydrogen, ii. 212
— bile, iii. 187
— borurets, ii. 22
— cobalt, blue, ii. 191
— muriatic acid, i. 341
— —— ether, iii. 159
— nitric ether, iii. 156
— osmazome, iii. 207
— oxides of iron, ii. 113
— —— nickel, ii. 233
— oxygenated water, i. 339; ii. 78
— potassium, ii. 28
— starch, iii. 17, 33
— vegetable substances, iii. 16
— wax, iii. 54
Theory, atomic, i. 220
of colour, i. 292
— crystallization, i. 197
— definite proportions, i. 220, 340
— electricity, i. 283
— falling stones, ii. 289
— formation of sulphuric acid, i. 392
— the earth, iii. 230
— radiation, i. 297, 308
— Voltaic pile, i. 279
Thermometer, its history, i. 86
Thermometer, its invention attributed to Drebbel, i. 86
— —— Santorio, i. 86
— —— Van Helmont, i. 87
— construction, i. 229
— graduation, i. 88, 229
— different scales, i. 229
air, i. 231
centigrade, i. 90, 229
De Lisle's, i. 230
Fahrenheit's, i. 90, 229
Leslie's differential, i. 231
mercurial, i. 229
photometric, i. 300
Reaumur's, i. 90, 229
spirit, i. 230
—— invented by the Academicians del Cimento, i. 87
Wollaston's, i. 241
Thomson on acetate of copper, iii. 167
on Allanite, ii. 197, 434
— arseniates of copper, ii. 209
— arsenic acid, ii. 206
— arsenious acid, ii. 205
— blende, ii. 391
— chloride of lime, ii. 63
— —— sulphur, i. 397
— hydrated sulphur, i. 387
— malt, iii. 32
— muriatic ether, iii. 159
— nitric ether, iii. 157
— oxalate of ammonia and copper, iii. 91
— oxymuriate of lime, ii. 63
— periodide of phosphorus, i. 410
— phosphuret of carbon, i. 453
— phosphuretted hydrogen gas, i. 411
— proof spirit, iii. 144
— sodalite, ii. 315, 363
— sulphocyanic acid, i. 451
— test for gum, iii. 19
— —— starch, iii. 31
— tungstic acid, ii. 226

Thorina, ii. 331, 482
    procured, ii. 331, 483
    its properties, ii. 331
Thorinum, ii. 4, 331
Thumerstone, ii. 317
Thunder, i. 281
    house, i. 281
    storm electrical, i. 279
Tile ore, ii. 149
Tilted steel, ii. 129
Tin mine, Carglaise, iii. 271
Tin, ii. 139, 521
    assay of ores of, ii. 401
    compounds of, analyzed, ii. 396
    characters of the salts of, ii. 146, 521
    and gold, ii. 288
    foil inflamed by nitrate of copper, ii. 153
    plate, ii. 127
    powdered, ii. 140
    precipitation of gold by, ii. 287
    putty, ii. 141
    pyrites analyzed, ii. 399
    stone analyzed, ii. 396
    stream, ii. 141
    its acetate, iii. 166, 350
    — acid, ii. 143
    — alloys, ii. 127, 140
    — arseniate, ii. 209, 532
    — benzoate, iii. 105
    — bisulphuret, ii. 144, 522
    — borate, ii. 145
    — butter, ii. 142
    — carbonates, ii. 145
    — chlorides, ii. 141, 522
    — —— analyzed, ii. 398
    — citrate, iii. 349
    — expansion by heat, i. 224
    — hydrates, ii. 140
    — hydrosulphuretted oxide, ii. 145
    — hyposulphite, ii. 145
    — iodide, ii. 143, 522
    — muriate, ii. 142, 522
    — —— a test for gold, ii. 142, 287
Tin, muriate of, a test for platinum 293
    — nitrates, ii. 144, 522
    — ores, ii. 139, 141
    — —— analysis of, ii. 396
    — oxalate, iii. 90, 346
    — oxides, ii. 140, 348, 521
    — —— analysis of, ii. 396
    — oxymuriate, ii. 143
    — peracetate, iii. 166
    — peroxide, ii. 140, 522
    — phosphate, ii. 145
    — phosphite, ii. 145
    — phosphuret, ii. 145, 522
    — preparation, ii. 139
    — properties, ii. 139
    — protacetate, iii. 166
    — protoxide, ii. 140, 521
    — salts, table of, ii. 521
    — succinate, iii. 68, 346
    — sulphate, ii. 145, 522
    — sulphite, ii. 145
    — sulphuret, ii. 144, 522
    — tartrate, iii. 83, 347
    — —— with potassa, iii. 83
    — tests, i. 151; ii. 146, 348, 521
    — use in dyeing, iii. 50, 51
Tincal, ii. 56
Tincture of galls, a test for iron, i. 1
    tartar, iii. 145
Tinctura ferri muriatis, ii. 117
Tinning, ii. 162
Titanite, ii. 195
    analyzed, ii. 431
Titanium, ii. 4, 195
    its carbonate, ii. 196
    — muriate, ii. 196
    — nitrate, ii. 196
    — ores, ii. 195
    — —— analysis of, ii. 431
    — oxide, ii. 195, 196, 344
    — preparation, ii. 196
    — properties, ii. 196
    — tests, ii. 197, 344, 530

Todd on the electrical ray or torpedo, i. 282
Tombac, ii. 161
Topaz, oriental, i. 254; ii. 312
 occidental, ii. 313
 a good conductor of heat, i. 235
Torpedo, i. 282
Torricellian vacuum, i. 370
Torricelli on the pressure of the atmosphere, i. 370
Tors of Cornwall, iii. 272
Tourmaline, i. 254; ii. 316
 green, ii. 471
Tragacanth gum, iii. 20
Transition rocks, iii. 242, 249, 275
 limestone, iii. 284
Transmission of elements by electricity, i. 274
Transmutation of metals, i. 6
 account of a case of, i. 19
Transparency, i. 287
Transparent soap, iii. 57
Transpiration of plants, i. 105; iii. 6
Trap rocks, iii. 298
Treacle, iii. 21, 26
Trees, growth of, i. 110
Tremolite, ii. 318
Triphane, ii. 57, 315, 368
Triple prussiate of potassa, ii. 124
 calculus, iii. 200
Trismegistus, Hermes, i. 6
 works attributed to him, i. 7
Tritoxide of lead, ii. 164, 526
 manganese, ii. 105, 517
Trommsdorff on valerian, iii. 110
Tronc, ii. 55
Troubles in coal-mines, iii. 293
Trough, pneumatic, i. 128, 312
 mercurial, i. 128, 321
 voltaic, i. 270
Tube, detonating, i. 333
 of safety, i. 343
 luminous spiral, i. 259
Tunbridge waters, ii. 502
Tungstate of ammonia, ii. 227
Tungstate of lime, ii. 226, 535
 — —— analyzed, ii. 458
 — magnesia, ii. 226
 — manganese, ii. 228, 535
 — potassa, ii. 227
 — silver, ii. 542
 — soda, ii. 228
Tungsten, i. 170; ii. 3, 225, 535
 obtained, ii. 225
 its properties, ii. 225
 — acid, ii. 226, 343, 535
 — oxides, ii. 225
 — ores analyzed, ii. 452
 — tests, ii. 343
 — preparations, ii. 226, 535
Tungstic acid, ii. 226, 343, 535
 —— its properties, ii. 226
 oxide, ii. 225
Tuputi on nickel, ii. 232
Turf, iii. 77
Turmeric, i. 142; iii. 110
Turnip, composition of, iii. 37
Turnsole, iii. 125
Turpentine, oil of, its expansion by heat, i. 225
 latent heat of vapour of, i. 245
 artificial camphor formed from, iii. 63
Turpeth mineral, ii. 257
Tutenag, ii. 161
Types, metal of, ii. 182

ULMIN, iii. 38
 artificial, iii. 43
Ultimate analysis, i. 223; iii. 11
 principles of vegetables, iii. 10
 —— animal substances, iii. 172
Ultramarine, ii. 319
Uranite, ii. 193
 analyzed, ii. 429
Uranitic mica, ii. 193, 429
Uranium, ii. 4, 193, 529
 its acetate, iii. 160

Uranium, its arseniate, ii. 210
its benzoate, iii. 106
— characters, ii. 193
— chloride, ii. 193
— citrate, iii. 96
— compounds analyzed, ii. 428
— nitrate, ii. 194
— ores, ii. 193
— —— analyzed, ii. 428
— oxalate, iii. 92
— oxides, ii. 193, 344, 428, 530
— preparation, ii. 193
— subnitrate, ii. 194
— sulphate, ii. 194
— sulphuret, ii. 193, 194
— tartrate, iii. 85
— tests, ii. 195, 324, 530
Urate of ammonia, iii. 193, 201
Urates, iii. 193
Ure on sulphuric acid, i. 391
Urea, iii. 195
obtained, iii. 195
properties of, iii. 196
combines with metallic oxides, iii. 196
nitrate of, iii. 195
composition of, iii. 196
Uric acid, iii. 192, 199, 200, 350
composition of, iii. 193
in urine of birds and snakes, iii. 199
Urinary calculi, i. 170; iii. 199
principles contained in, iii. 200
appearances of, iii. 199, 200
varieties of, iii. 200
Urine, iii. 190
analysis of, iii. 197
composition of, iii. 191, 197
carbonic acid of, iii. 192
calculi in, iii. 199
changes of in disease, iii. 197
diabetic, iii. 197
free acid in, iii. 191
fusible salt of, iii. 194
gravel in, iii. 199
Urine, peculiar acid of (uric), iii. 192
phosphoric acid of, iii. 192
sugar of, iii. 197
of graminivorous animals, iii. 199

VACUO, ice procured in, i. 122, 247
radiation of heat in, i. 298
Vacuum, Torricellian, i. 370
Valentine, Basil, i. 28, 97
Valerian, iii. 110
Value of light from different sources, i. 441
Van Helmont, i. 17, 41, 97
air thermometer described by, i. 87
his tincture of tartar, iii. 145
Vaporization, i. 121
produces cold, i. 243
hastened by heat, i. 241
Vapours, i. 241
formed by heat, i. 241
force of, i. 243
expansion of by heat, i. 225
latent heat of, i. 245
are compounds of fluids and heat, i. 244
— electrical, i. 268
Varnish, iii. 57
Varnishes, iii. 69
Vauquelin on acetate of tin, iii. 166
— axinite, ii. 317
— artificial gum, iii. 34
— asparagin, iii. 41
— bitter principle, iii. 40
— bones, iii. 215
— cerebral substance, iii. 212
— cerite, ii. 432
— cerium, ii. 198
— chlorate of copper, ii. 152
— —— mercury, ii. 251
— chromium, ii. 4, 221
— —— ores, ii. 451
— colouring matter of blood, iii. 180
— cyanogen, i. 447
— galena, analysis of, ii. 412

- *Vauquelin* on garnet, ii. 314
  - on glucina, ii. 328
  - — hair, iii. 208
  - — iodine, i. 324
  - — kinic acid, iii. 108
  - — lactic acid, iii. 185
  - — lithia, ii. 59
  - — lobster-shell, iii. 214
  - — lupine seeds, iii. 120
  - — malic acid, iii. 97, 98
  - — meteoric stones, ii. 240
  - — nicotin, iii. 40
  - — nightshade, iii. 116
  - — onion, iii. 124
  - — sap of plants, iii. 8
  - — sulphuret of potassa, ii. 45
  - — tartrate of potassa and soda, iii. 81
  - — titanium, ii. 196
  - — —— ores, ii. 431
  - — tungstates, ii. 227
  - — varieties of potassa, ii. 45
  - — zeolite, ii. 313
- *Vegetable substances*, iii. 1
  - composition of, iii. 10, 16
  - analysis of, i. 177; iii. 10
  - general laws of their composition, iii. 16
  - table of their composition, iii. 17, 127, 345
  - —— nutritive matters, iii. 127
- *Vegetable* acids, iii. 78, 122
  - —— table of, iii. 345
  - albumen, iii. 36
  - alcali, ii. 32, 43
  - alcalies, iii. 69, 72
  - butters, iii. 55
  - chemistry, iii. 1
  - extract, iii. 38
  - nutritive principles, iii. 36
- *Vegetables*, growth of, iii. 5
  - proximate principles of, iii. 17
  - ultimate principles of, iii. 10
  - effects of light on, i. 179, 203
- *Vegetation*, purification of air by, i. 132; iii. 6
  - chemical phænomena of, iii. 2, 6
  - Hales on, i. 104
- *Veins*, mineral, iii. 304
  - granitic, iii. 256, 257
  - metallic, iii. 304
  - their accidents, iii. 305
  - —— ages, iii. 307
  - —— direction, iii. 305
  - —— formation, iii. 306
  - —— indications, iii. 307
- *Velocity of light*, i. 286
- *Venel*, i. 141
- *Venous blood*, iii. 221
- *Ventilation*, i. 227
- *Verd antique*, ii. 72
- *Verdigris*, i. 195; iii. 162, 167
  - its composition, iii. 167
- *Verditer*, ii. 159
- *Vermilion*, ii. 255
- *Vesuvian*, ii. 314
- *Vicat on mortars*, ii. 325
- *Vinegar*, iii. 160
  - production of, iii. 160
  - purification of, iii. 161
  - properties of, iii. 161
  - latent heat of its vapour, i. 245
  - distilled, iii. 161
  - pyroligneous, i. 47; iii. 162
  - radical, iii. 161
  - of wood, i. 47; iii. 162
- *Vinous fermentation*, iii. 128, 130
- *Vinum ferri*, ii. 117
- *Violet-coloured vapours from iodine*, i. 324
- *Violets, tincture of*, i. 215
- *Vision*, i. 286
- *Vitreous electricity*, i. 250
  - silver ore, ii. 270
- *Vitrifiable lute*, i. 408
- *Vitriol*, blue, ii. 160
  - green, ii. 119
  - of iron, ii. 119
  - Roman, ii. 156

Vitriol, white, ii. 137
oil of, i. 389
of venus, ii. 157
of zinc, ii. 137
Vitriolic acid, i. 389, 467
air, i. 136, 388
Vogel on oxalate of lime, iii. 89
on oxalate of ammonia and copper, iii. 91
—scillitin, iii. 125
— sulphovinous acid, iii. 158
Volatile alcali, i. 361
liver of sulphur, i. 400
oils, iii. 58
—— table of, iii. 59
—— properties of, iii. 60
—— quantities afforded by different substances, iii. 61
Volatility of the metals, ii. 11
Volcanic rocks, iii. 243, 314
Volcanoes, formation of, iii. 314
phænomena of, iii. 314
Volta, i. 187
Volta's eudiometer, i. 380
lamp, i. 330
pile, i. 187
Voltaic apparatus, i. 187, 269
—— of Dr. Wollaston, i. 278
battery of Mr. Children, i. 276
combinations, chemical properties of, i. 269
electricity, i. 268
—— laws of, i. 273
—— diverges the electrometer, i. 275
—— intensity of, i. 276
—— quantity of, i. 276
—— chemical agencies of, i. 187, 273
—— decomposition of water by, i. 273, 335
—— heat produced by, i. 187, 273
—— combustion of metals by, i. 273 ii. 12
light, i. 272, 341
Voltaic light induces chemical action, i. 341
phænomena, i. 272
pile, i. 187, 270
—— improvement of, i. 278
—— experiments with, i. 187
—— theory of, i. 279
trough, i. 270
Vomica nut, iii. 72
Vulpinite, ii. 68

WALKER on freezing mixtures, i. 239
Wash, iii. 130
Water, i. 330, 464
discovery of its composition by Cavendish, i. 160
contains air, i. 339
quantity of gases absorbed by, i. 340
a bad conductor of heat, i. 237
convertible into steam, i. 338
becomes luminous by sudden compression, i. 338
of crystallization, i. 194, 339
of the atmosphere, i. 384
combined with oxygen, i. 339; ii. 78
and alcohol, iii. 136
barytes, ii. 78
distilled, i. 337
gilding, ii. 291
hard, i. 336; iii. 57
—— test for, iii. 57
lime, ii. 62
oxygenated, i. 339; ii. 78
rain, i. 336
river, i. 336
sea, analysis of, ii. 96
soft, i. 336
spouts, i. 282
spring, i. 336
strontian, ii. 90
trough, pneumatic, i. 128
its action on metals, ii. 15
— analysis, i. 160, 330, 334

Water, its anomalous expansion, i. 91, 228, 462
— boiling point, i. 338
— capacity for heat, i. 232
— composition, i. 160, 220, 330, 341, 464
— compressibility, i. 338
— crystallization, i. 338
— decomposition by Voltaic electricity, i. 273, 335
— —— potassium, ii. 30
— —— iron, i. 161, 334
— —— phosphuret of lime, ii. 68
— —— chlorides of phosphorus, i. 409
— expansion by cold, i. 91, 228, 338, 462
— —— freezing, i. 228
— —— heat, i. 225, 462
— formation by slow combustion, i. 331
— —— rapid combustion, i. 333
— latent heat, i. 120
— production, i. 161, 331
— properties, i. 336, 338
— refraction, i. 288
— solidification by cold, i. 338
— —— combination, i. 241
— specific gravity at different temperatures, i. 462
— synthesis, i. 330, 331
— tests for hardness, i. 145; iii. 57
— vaporization, i. 338
— weight, i. 338, 462
Waters, chalybeate, ii. 490, 502
carbonated, ii. 502
hard, test for, i. 145; iii. 57
medicated artificial, i. 147
mineral, i. 141; ii. 487, 502
—— table of, ii. 502
—— examination of by tests, ii. 487
—— analysis of, i. 146; ii. 484, 491
—— tests required for their examination, ii. 486
Water, sulphurous, ii. 502
saline, ii. 502
Watt, notice of, i. 124
on the steam-engine, i. 123
— basalt, iii. 300
Wavellite, ii. 312
Wax, iii. 53, 345
its composition, iii. 54
— phosphorescence, i. 304
artificial, iii. 209
Wedgewood on specific heat, i. 234
on feldspar, iii. 253
— ignition of air, i. 305
— manufacture of crucibles, ii. 322
— use of sulphate of baryta in porcelain, ii. 85
Weight, specific, ii. 6
of gases, i. 374
— —— table of, i. 379
— atmospheric air, i. 373
— elements and their compounds, i. 464
— water, i. 338
Weights, English, i. 457
—— reduced to French, i. 459
French, i. 459
—— reduced to English, i. 461
Weld, iii. 50
Welding of platinum, ii. 296
Welther on artificial bitter principle, iii. 40
Wernerian theory of the earth, iii. 242, 257
Westrumb on boracite, ii. 471
Wheat, iii. 36
Whey, iii. 183, 184
Whinstones, iii. 298
origin of, iii. 300
Whiskey, iii. 185
Whiston's theory of the earth, iii. 237
Whitbread's brewery heated by steam, i. 246
White arsenic, ii. 203
cast-iron, ii. 127
copper, ii. 242

White cobalt glance, analysis of, ii. 425
enamel, ii. 140, 305
flux, ii. 37
granular limestone, ii. 71
lead, ii. 170
lias limestone, iii. 293
light proportion of coloured rays in, i. 292
oxide of bismuth, ii. 184
pearl, ii. 185
permanent, ii. 86
precipitate, ii. 251
sand of urine, iii. 193, 199
silver ore, analysis of, ii. 463
vitriol, ii. 137
Whitehurst's theory of the earth, iii. 237
Wiegleb on Manheim gold, ii. 161
Wilson, his double multiplier, i. 266
on solar phosphori, i. 304
Wilson's hygrometer, i. 385
Wind furnace, i. xiii. xv.
Wine, iii. 130
constituent parts of, iii. 130
quantity of alcohol in, iii. 132
oil of, iii. 153
spirit of, iii. 131
Wire-gauze lamp, i. 444
extinction of flame by, i. 307, 443
Wire, tenacity of, ii. 9
Withering on baryta, ii. 374
Witherite, ii. 88
Wolfram, ii. 225, 454
Wolframium, ii. 225
Wollaston on cadmium, ii. 147
on calculi, iii. 202
— columbium, ii. 454
— columbite, ii. 229
— crystallization, i. 208
— definite proportion, i. 84, 222
— iridium, ii. 263
— number of lime, ii. 373
— ores of platinum, ii. 468
— palladium, ii. 4, 265
— radiant matter, i. 301
Wollaston on rhodium, ii. 4, 264
— separation of magnesia, ii. 100
his cryophorus, i. 122, 247
— goniometer, i. 200
— scale of chemical equivalents, i. 84, 222
— theory of crystallization, i. 208
— Voltaic apparatus, i. 278
Wood on platinum, ii. 3
Wood, iii. 3
Wood ash, ii. 43
mountain, ii. 318
tin, ii. 141
vinegar distilled from, i. 47, 162
Woods, iii. 114
quantity of charcoal afforded by, i. 418
conducting powers of, for heat, i. 235
Woody fibre, iii. 42
—— converted into gum, iii. 42
—— —— into sugar, iii. 43
Woodward on prussian blue, ii. 123
Woodward's theory of the earth, iii. 235
Wool, iii. 208
Wootz, ii. 130
analysis of, ii. 387
artificial, ii. 308
Wort, iii. 128
Woulfe, Peter, anecdotes of, i. 25
on aurum musivum, ii. 144
his apparatus, i. 51, 313
—— contrived by Glauber, i. 51
Writing ink, receipt for, iii. 102
how restored when decayed, iii. 102
Wrought iron, ii. 128

XANTHIC OXIDE, iii. 202

YEAST, iii. 129
Yellow dye, iii. 5

Yellow, mineral or patent, ii. 165
ore of tellurium analyzed, ii. 436
Yolk of eggs, iii. 211
Young, Dr., on globules of the blood, iii. 180
Yttria, its sources, ii. 330, 482
how procured, ii. 330
its properties, ii. 330
Yttrium, ii. 330
Yttro-tantalite, ii. 229

ZAFFRE, ii. 192
Zeolite, varieties of, ii. 313
analysis of, ii. 313
Zimoma, iii. 36
Zinc, ii. 3, 133, 520
its acetate, iii. 166, 350
— alloys, ii. 139
— ammoniuret, ii. 135
— arseniate, ii. 209, 532
— benzoate, iii. 105
— borate, ii. 138, 521
— butter, ii. 134
— carbonate, ii. 137, 521
— chlorate, ii. 135, 520
— chloride, ii. 134, 520
— —— analyzed, ii. 390
— citrate, iii. 95, 349
— compounds analyzed, i. 389
— expansion by heat, i. 224
— hydriodate, ii. 135, 520
— hyposulphite, ii. 136, 521
— iodate, ii. 135, 520
— iodide, ii. 135, 520
Zinc, its muriate, ii. 134, 520
— nitrate, ii. 135, 520
— ores, ii. 133, 136, 137
— —— assayed, ii. 396
— oxalate, iii. 90, 344
— oxide, ii. 134, 346, 520
— —— analyzed, ii. 390
— phosphate, ii. 137, 521
— phosphuret, ii. 137, 521
— preparation, ii. 133, 138
— properties, ii. 133
— prussiate, ii. 138
— succinate, iii. 68, 346
— sulphate, ii. 136, 521
— sulphite, ii. 136, 521
— sulphuret, ii. 136, 521
— —— analyzed, ii. 391, 393
— sulphuretted sulphite, ii. 136
— tartrate, iii. 83, 346
— tests, ii. 136; 346, 520
and gold, ii. 288
flowers of, ii. 134
Zincane (chloride of zinc) ii. 134
Zinc spinelle, ii. 312
Zinci oxydum, ii. 134
sulphas, ii. 137
Zircon, ii. 326
analyzed, ii. 478
Zirconia, its sources, ii. 326, 478
preparation, ii. 327, 478
properties, ii. 326, 479
Zirconium, ii. 326
its oxide, ii. 326, 47
Zoophytes, iii. 214
Zumic acid, iii. 10

THE END.

LONDON:
PRINTED BY WILLIAM CLOWES,
Northumberland-court.

BIBLIOTHECA BODLEIANA